[illegible] CD equal [illegible]
[illegible] HZD,
[illegible] to HDS. Then the arc Zr equal the [illegible] CZ, and [illegible] thence to G, [illegible] DL equal the Moon's altitude, and [illegible]. Lastly, draw the parallels of [illegible] LM, PS, and MN, measured on the line of *equal Parts*, will be the First correction in *Minutes*, — or + according as N is to the right or left of M.

## *To find the* SECOND *Corr. for the Moon's Refraction.*

With the Moon's altitude enter column B in the annexed Table, and take out the corresponding number in column A, P; then,

as P . CD : 60″ : : MN : the second corr. in [illegible] + or —, as MN is — or +.

## *To find the* THIRD *Correction for the Sun's or Star's Refraction.*

Apply SN to the line of *equal Parts*, and with the altitude of the object, take out the Tab. numb. as before (Q) and

as Q . CD : 60″ : : SN : the Third Corr. in *seconds*, — or + as N is to the right or left of S.*

If greater [illegible] required, the following

FOURTH *Correction must be used.*

Let T, R, V, respectively denote the Tab. numbers in column C, corresponding to the Apparent Distance in column B, and to the Parallaxes in Distance (MN) and the Moon's altitude (R [illegible] Tab. XII) in column D. Then

as 90 [illegible] T : : [illegible] V : the Fourth correction in *seconds*, which is [illegible] if the apparent [illegible] be less than 90 degrees, otherwise —.

---

* If the Observation be made with the Sun, a small correction must be applied for parallax, which is = SN ÷ 7 in *seconds*, [illegible] — as the third correction is — or +.

[illegible] HZD, [illegible] to HDS. Then the arc Zz equal the [illegible] CZ, and proceed [illegible] then of C[illegible] equal the Moon's altitude, and [illegible] Sun or Star. Lastly, draw the parallels of alt. LM, PS, and MN; measured on the line of *equal Parts*, will be the First correction in *Minutes*, — or + according as N is to the right or left of M.

### *To find the* SECOND *Corr. for the Moon's Refraction.*

With the Moon's altitude enter column B in the annexed table, and take the corresponding number in column A, P; then,

as P.CD : 60″ : : MN : the second corr. in seconds, + or —, as MN is — or +.

### *To find the* THIRD *Correction for the Sun's or Star's Refraction.*

Apply SN to the line of *equal Parts*, and with the altitude of the object, take out the Tab. numb. as before (Q), and

as Q.CD : 60″ : : SN : the Third Corr. in seconds, — or +, as N is to the right or left of S.*

If greater accuracy be required, the following

FOURTH *Correction must be used.*

Let T, R, V, respectively denote the Tab. numbers in column C, corresponding to the Apparent Distance in column B, and to the Parallaxes in Distance (MN) and the Moon's altitude (Ref. Tab. XII.) in column D. Then,

as 90 : RT : : [illegible] V : the Fourth correction in seconds, which is + if the apparent distance be less than 90 degrees, otherwise —.

---

* If the Observation be made with the Sun, a small correction must be applied for parallax, which is = SN ÷ 7 in seconds, either — or + as the third correction is — or +.

[illegible]

# of clearing the Lunar Distances from the Effects of Parallax and Refraction.

### EXAMPLE.

| | ° | ′ | ″ |
|---|---|---|---|
| Apparent Distance of Centres | 50 | 8 | 41 |
| Moon's Altitude | 55 | 56 | 0 |
| Star's Altitude | 19 | 18 | 0 |
| Moon's Horizontal Parallax | | 60 | 5 |

Required the true Distance.

n Line of equal Parts, is $60\frac{1}{11}$, Moon's Horizontal Parallax.

·88, Q = ·351 ·

| | | ° | ′ | ″ |
|---|---|---|---|---|
| CD. | Zz is the arc of | 50 | 8 | 41 |
| | DL | 55 | 56 | 0 |
| | EP | 19 | 18 | 0 |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Apparent Distance of Centres | | 50 | 8 | 41 |
| Corr. MN, on Line of equal Parts, is $15\frac{3}{4}$ | + | | 15 | 45 |
| d Corr. as $\cdot 88 \times 60\frac{1}{11} : 60'' :: 15\frac{3}{4} :$ | − | | | 17 |
| N, Line equal Parts, is 48. | | | | |
| d Corr. as $\cdot 351 \times 60\frac{1}{11} : 60'' :: 48 :$ | + | | 2 | 16 |
| =6·2, R=3·6, V=(34′) 14·5. | | | | |
| h Corr. as $90 : 8 \times 6{\cdot}2 :: 10{\cdot}9 :$ | + | | | 6 |
| True Distance | | 50 | 26 | 31 |

tion be performed with the accuracy it admits of from the inch decimal s

ector, the result may be depended on in all cases to within two or three seco

| Reduced Refractions. | App. Alt. and App. Diſt. | Tab. Numb. | | Parallax in Alt. and Diſt. | Reduced Refractions. | App. Alt. and App. Diſt. | Tab. Numb. | | Parallax in Alt. and Diſt. |
|---|---|---|---|---|---|---|---|---|---|
| A | B | C | | D | A | B | C | | D |
| | Deg. | | | Min. | | Deg. | | | Min. |
| ·1006 | 5 | | | | ·9393 | 63 | 3·9 | ·7 | 7 |
| ·1175 | 6 | | | | ·9394 | 64 | 3·8 | ·5 | 6 |
| ·1353 | 7 | | | | ·9753 | 65 | 3·7 | ·4 | 5 |
| ·1527 | 8 | | | | ·9762 | 66 | 3·6 | ·2 | 4 |
| ·1703 | 9 | | | | ·9768 | 67 | 3·4 | ·1 | 3 |
| ·1876 | 10 | 45· | 45· | 60 | ·9772 | 68 | 3·2 | ·09 | 2 |
| ·2052 | 11 | 40·5 | 43·6 | 59 | ·9774 | 69 | 3·1 | 0 | 1 |
| ·2232 | 12 | 37·2 | 42·3 | 58 | ·9776 | 70 | 3· | | |
| ·2406 | 13 | 34·3 | 41·1 | 57 | 1·0281 | 71 | 2·8 | | |
| ·2587 | 14 | 32· | 40· | 56 | 1·0301 | 72 | 2·7 | | |
| ·2760 | 15 | 30· | 38·5 | 55 | 1·0319 | 73 | 2·5 | | |
| ·2928 | 16 | 28· | 37· | 54 | 1·0337 | 74 | 2·3 | | |
| ·3118 | 17 | 26·3 | 35·6 | 53 | 1·0353 | 75 | 2·2 | | |
| ·3280 | 18 | 25·2 | 34·3 | 52 | 1·0368 | 76 | 2· | | |
| ·3459 | 19 | 23·7 | 33· | 51 | 1·0382 | 77 | 1·9 | | |
| ·3638 | 20 | 22·5 | 31·8 | 50 | 1·0396 | 78 | 1·7 | | |
| ·3811 | 21 | 22·1 | 30·5 | 49 | 1·0408 | 79 | 1·6 | | |
| ·3974 | 22 | 21·7 | 29·3 | 48 | 1·0419 | 80 | 1·4 | | |
| ·4122 | 23 | 20·3 | 28·1 | 47 | 1·0429 | 81 | 1·2 | | |
| ·4316 | 24 | 18·8 | 27· | 46 | 1·0438 | 82 | 1·1 | | |
| ·4457 | 25 | 17·9 | 25·9 | 45 | 1·0446 | 83 | ·9 | | |
| ·4649 | 26 | 17· | 24·8 | 44 | 1·0453 | 84 | ·8 | | |
| ·4816 | 27 | 16·2 | 23·4 | 43 | 1·0459 | 85 | ·7 | | |
| ·4951 | 28 | 15·3 | 22· | 42 | | 86 | ·6 | | |
| ·5145 | 29 | 14·6 | 21· | 41 | | 87 | ·4 | | |
| ·5302 | 30 | 14· | 20· | 40 | | 88 | ·2 | | |
| ·5414 | 31 | 13·6 | 19· | 39 | | 89 | ·1 | | |
| ·5592 | 32 | 13·3 | 18· | 38 | | 90 | ·0 | | |
| ·5718 | 33 | 12·7 | 17·1 | 37 | | 91 | ·1 | | |
| ·5922 | 34 | 12·2 | 16·2 | 36 | | 92 | ·2 | | |
| ·6068 | 35 | 12· | 15·4 | 35 | | 93 | ·4 | | |
| ·6223 | 36 | 11·8 | 14·5 | 34 | | 94 | ·6 | | |
| ·6305 | 37 | 11·4 | 13·7 | 33 | | 95 | ·7 | | |
| ·6477 | 38 | 11· | 13·1 | 32 | | 96 | ·8 | | |
| ·6661 | 39 | 10·5 | 12·1 | 31 | | 97 | ·9 | | |
| ·6759 | 40 | 10· | 11·2 | 30 | | 98 | 1·1 | | |
| ·6967 | 41 | 9·5 | 10·7 | 29 | | 99 | 1·2 | | |
| ·7078 | 42 | 9·1 | 10·2 | 28 | | 100 | 1·4 | | |
| ·7194 | 43 | 8·7 | 9·6 | 27 | | 101 | 1·6 | | |
| ·7315 | 44 | 8·3 | 9· | 26 | | 102 | 1·7 | | |
| ·7443 | 45 | 8· | 8·4 | 25 | | 103 | 1·9 | | |
| ·7578 | 46 | 7·8 | 7·7 | 24 | | 104 | 2· | | |
| ·7721 | 47 | 7·4 | 7·1 | 23 | | 105 | 2·2 | | |
| ·7872 | 48 | 7· | 6·4 | 22 | | 106 | 2·3 | | |
| ·8033 | 49 | 6·6 | 5·9 | 21 | | 107 | 2·5 | | |
| ·8035 | 50 | 6·2 | 5·5 | 20 | | 108 | 2·7 | | |
| ·8209 | 51 | 5·9 | 5· | 19 | | 109 | 2·8 | | |
| ·8395 | 52 | 5·7 | 4·5 | 18 | | 110 | 3· | | |
| ·8397 | 53 | 5·5 | 4·1 | 17 | | 111 | 3·1 | | |
| ·8602 | 54 | 5·3 | 3·8 | 16 | | 112 | 3·2 | | |
| ·8604 | 55 | 5·1 | 3·4 | 15 | | 113 | 3·4 | | |
| ·8829 | 56 | 4·9 | 3 | 14 | | 114 | 3·6 | | |
| ·8832 | 57 | 4·7 | 2·6 | 13 | | 115 | 3·7 | | |
| ·9084 | 58 | 4·5 | 2·2 | 12 | | 116 | 3·8 | | |
| ·9089 | 59 | 4·3 | 1·8 | 11 | | 117 | 3·9 | | |
| ·9091 | 60 | 4·2 | 1·4 | 10 | | 118 | 4· | | |
| ·9098 | 61 | 4·1 | 1·1 | 9 | | 119 | 4·1 | | |
| ·9894 | 62 | 4· | 9· | 8 | | 120 | 4·2 | | |

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Disp.: [illegible]

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THE

# SEAMAN'S DESIDERATA:

OR,

CONCISE, PRACTICAL RULES

FOR COMPUTING

THE APPARENT TIME AT SEA,

THE

LATITUDE

*FROM DOUBLE SOLAR ALTITUDES,*

AND THE

LONGITUDE

*FROM THE LUNAR OBSERVATIONS.*

WITH

A SIMPLE AND EXPEDITIOUS METHOD OF CLEARING
THE LUNAR DISTANCES

FROM THE

EFFECTS OF PARALLAX AND REFRACTION.

*By H. CLARKE,*

LECTURER IN MATHEMATICS AND PHILOSOPHY.

BRISTOL:

*PRINTED BY RICHARD EDWARDS, BROAD-STREET.*

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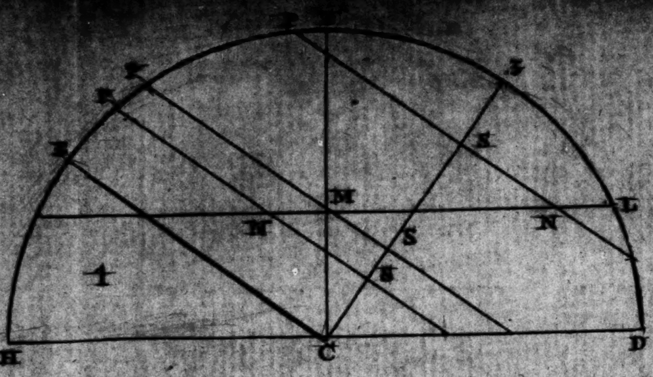
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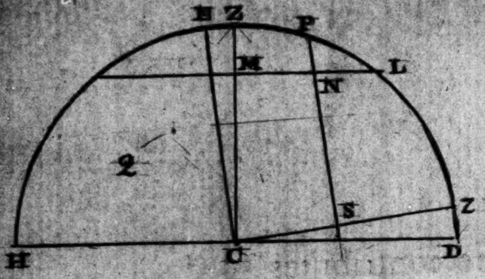
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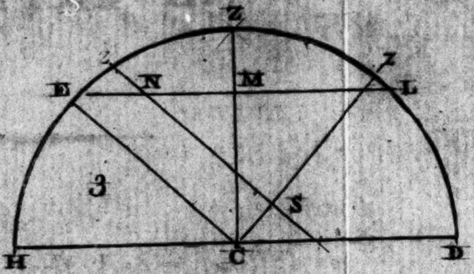
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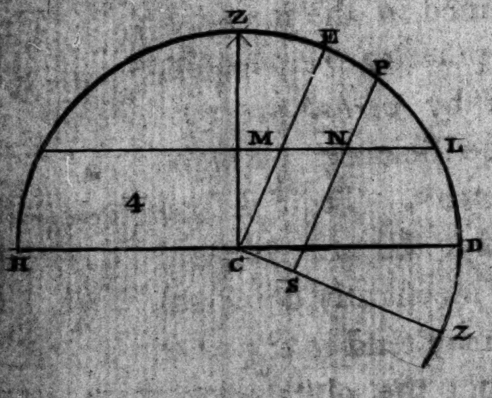
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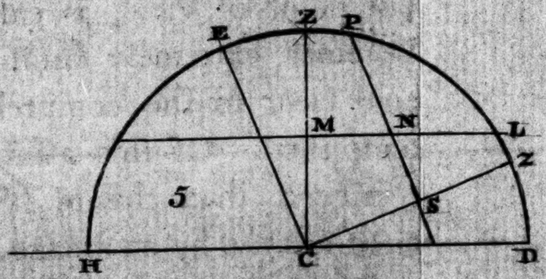
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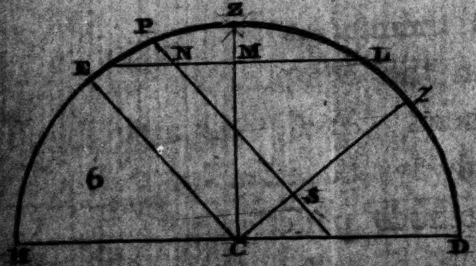
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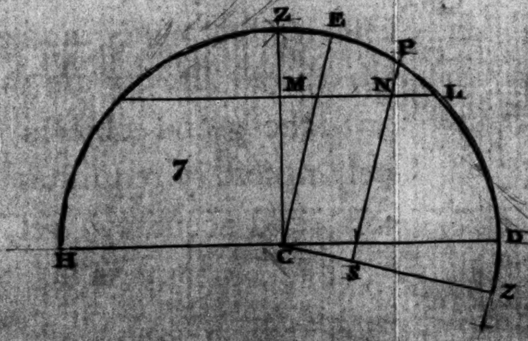
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# ADVERTISEMENT.

IT is univerſally allowed, that nothing more contributes to the facilitating of numeral computations than General Theorems or *Formulæ*; as thereby, the mode of operation, which is then exhibited in one point of view, is eaſily retained in the memory, and ſoon becomes extremely familiar by practice; eſpecially, when rendered clear to the comprehenſion by *verbal* precepts properly exemplified. Of this aſſiſtance, no Science, perhaps, ſtands more in need, than that of NAVIGATION. Tedious and operoſe calculations are by no means adapted to the ſituation and buſy life of a Mariner at ſea, who is almoſt inceſſantly occupied in availing himſelf of every occurrence that may tend to expedite his progreſs on the voyage, and to ſurmount the obſtacles, or avoid the dangers, that every moment preſent themſelves before him. Simplicity and brevity are evidently, in the computative part of this art, the grand objects of attainment. And though theſe abſolutely neceſſary requiſites may not always be attended with the moſt rigid accuracy, yet, if the methods poſſeſſed of theſe advantages be found ſufficiently correct for the general purpoſes of Navigation, they muſt certainly, in point of utility, be preferable to more complicated proceſſes; the reſults of which, even in the moſt ſkilful hands, are often, through the almoſt unavoidable errors attending a long and troubleſome calculation, added to thoſe too frequently ariſing from the obſervations themſelves, ambiguous and uncertain.

Theſe remarks principally apply to the methods hitherto given of finding the Longitude at Sea by the obſerved lunar diſtances. For as theſe diſtances are only apparent, and in ſome caſes greater and in others leſs than the true diſtance (a circumſtance owing to refraction and parallax, with which the apparent place of every celeſtial body, unleſs when in the zenith of the obſerver, is more or leſs affected), they ſtand in need of a correction,—an operation that is univerſally conſidered as the moſt intricate and embarraſſing in the whole practice of nautical computation; and which has, by its forbidding aſpect, deterred many intelligent ſeamen from attempting the determination of the longitude by this procedure. The method here recommended for obtaining this correction is chiefly by a ſimple linear projection, which will be found, in general, to produce a reſult with ſurpriſing exactneſs; particularly if the obſerved altitudes be within the uſual limits with reſpect to the horizon and the zenith. The reaſon indeed of this conciſe operation may not be obvious to every one, having its origin in the nature of ſtereographics, and the increments of variable ſpheric triangles; but it is, notwithſtanding, ſo plain and expeditious in its performance, that the correction may, in all caſes, be aſcertained in a very few minutes. The buſineſs, therefore, of finding the Longitude at Sea by the lunar diſtances is, by this means, rendered ſo eaſy, that, in conjunction with that excellent and indiſpenſibly neceſſary performance, the Nautical Almanac, with its proper appendage, the Requiſite Tables,—a work which will for ever reflect the higheſt honor on its learned and truly noble-ſpirited author, our preſent Aſtronomer Royal, the Rev. Dr. **Maskelyne**,—the whole proceſs may be perfectly comprehended in one ſingle hour, by any man who can keep a common day's reckoning at Sea.

Thoſe who wiſh for greater preciſion than this conſtruction affords, muſt have recourſe to pure computation in correcting the lunar diſtances; for which purpoſe they will find the **Formula** here given not only new, but exceedingly conciſe, requiring only three logarithms in the whole operation: and it has alſo the advantage of perfect accuracy, being derived directly from the principles of ſpherics,—having the three ſides of a triangle given (the obſerved diſtance, and the two co-altitudes, or zenith diſtances) to find the vertical angle; and from thence, and the corrected co-altitudes, or ſides, to determine the baſe, or true diſtance required.

## *Abbreviations in the following Formulæ.*

| | | | |
|---|---|---|---|
| *D. R.* | Dead Reckoning. | *A. T.* | Approximate Time. |
| *N. A.* | Nautical Almanac. | *T. T.* | True Time. |
| *S.* | Sine. | *C.* | Coſine. |
| *N. S.* | Natural Sine. | *N. C.* | Natural Coſine. |
| *A. M.* | Before Noon. | *P. M.* | After Noon. |
| *R. A.* | Right Aſcenſion. | *G. A.* | Greater Altitude. |
| *L. L.* | Lower Limb. | *L. A.* | Leſs Altitude. |
| + | Addition. | — | Subtraction. |

N. B. To turn motion (ſpace) into time,—multiply the degrees, minutes, ſeconds, &c. by 4; the product will be hours, minutes, &c.——Time is converted into motion by dividing by 4.

## A concise FORMULA for finding the TRUE APPARENT TIME at SEA: and for correcting a TIME-PIECE.

### BY THE SUN.

| | | H. M. S. | ° ″ ′ | |
|---|---|---|---|---|
| GIVEN | Approx. time at Ship | - - - | | To find the Apparent Time, and Error of the Watch. |
| | Ship's lat. *(N. S.)* | | - - - | |
| | Ship's long. *(E. W.)* | | - - - | |
| | Sun's alt. *L. L.* | | - - - | |
| | Height of the eye | | - - - | |

Corrections.

| | | ° ″ ′ | |
|---|---|---|---|
| Sun's alt. *L. L.* | | - - - | |
| Dip. | — | - - - | II. R. T. |
| Refraction | — | - - - | I. R. T. |
| Parallax | + | - - - | III. R. T. |
| Sun's semid. | + | - - - | III. N. A. |
| Corr. alt. Sun's cent. | | - - - | |

| | | ° ″ | ° ″ ′ | |
|---|---|---|---|---|
| Sun's declin. noon Gr. | | | - - - | II. N. A. |
| Ship's long. | W. | - - + / − | - - - | VI. R. T. |
| | E. | - - − / + | | |
| App. time | P.M. | - - + / − | - - - | |
| | A.M. | - - − / + | | |
| Reduced declin. *(N. S.)* | | | - - - | |

Operation.

| | ° ″ ′ | | | |
|---|---|---|---|---|
| * Sun's zen. dist. | - - - | | | |
| Sun's polar dist. | - - - | Log. *S.* | + - - - - - - | |
| Co-latitude | - - - | Log. *S.* | + - - - - - - | |
| Diff. | - - - | Sum | − - - - - - - | |
| Half ſum | - - - | Log. *S.* | + - - - - - - | |
| Half diff. | - - - | Log. *S.* | + - - - - - - | |
| | | Sum | + - - - - - - | index + 20. |
| | - - - | Half diff. | - - - - - - | |
| Mult. by | 8 | | | |
| True app. time at Ship | - - - | | | |

Ope

Sum + - - - - - - index + 20.

Half diff. - - - - - -

- - -

Mult. by 8

True app. time at Ship - - -
Approx. time at Ship - - -

Diff. - - - Error of the Watch.

Corrections.

## BY A STAR.

*Data*, as above.

|  | ° | ′ | ″ |
|---|---|---|---|
| Star's observed alt. + | - | - | - |
| Dip. − | - | - | - |
| Refr. − | - | - | - |
| Star's true alt. | - | - | - |
| Star's red. declin. (*N. S.*) | - | - | - |
| Star's red. *R. A.* | - | - | - |

Star's red. declin. and Star's red. *R. A.* } VII. R. T.

|  | *H.* | *M.* | *S.* |
|---|---|---|---|
| Sun's *R. A.* noon Gr. | - | - | - |
| Ship's long. {E. − / W. +} | - | - | - |
| Sun's *R. A.* at noon, Ship | - | - | - |
| Approx. time {A. M. − / P. M. +} | - | - | - |
| Sun's red. *R. A.* | - | - | - |

The lines from Ship's long. to Approx. time } XXIII. R. T.

Operation.

Then proceed as above to find the Star's merid. dist. in time. *

|  | *H.* | *M.* | *S.* |  |
|---|---|---|---|---|
| Star's *R. A.* | - | - | - | (+ 24 *H.* if neceſſary.) |
| Sun's *R. A.* − | - | - | - |  |
| If {E. − / W. +} | - | - | - | Diff. |
| Star's merid. dist. + | - | - | - |  |
|  | - | - | - | Apparent time at Ship. |

If the Watch be supposed much erroneous, or the time not known, proceed thus:

|  | *H.* | *M.* | *S.* |  |
|---|---|---|---|---|
| Star's red. *R.* A. | - | - | - |  |
| Star's merid. dist. if W. + / E. − | - | - | - |  |
|  | - | - | - |  |
| Sun's *R. A.* noon at Ship − | - | - | - |  |
| Diff. | - | - | - | Approx. time |
| Corr. XXIII. R. T. − | - | - | - | for approx. time, and daily diff. Sun's *R. A.* |
| Rem. | - | - | - | Apparent time at Ship. |

# SEAMAN's DESIDERATA, &c.

## PROBLEM I.

*To find the apparent Time at Sea, having given the Latitude and Longitude of the Ship by D. R. the Sun's obſerved Altitude, and the approximate Time.*

### PREPARATION.

FROM the obſerved altitude of the Sun's lower limb, ſubtract the dip of the horizon and the refraction (I. II. R. T.) and to the remainder add the Sun's parallax (III. R. T.) and ſemidiameter (p. III. N. A.) the ſum will be the correct altitude of the Sun's centre.

Find the Sun's declination for the day (II. N. A.); then add or ſubtract for the Ship's longitude, and alſo for the time from noon (VI. R. T.) and the reſult will be the reduced declin. to the time and place of obſervation.

### PRECEPTS.

1. Take the diff. between the Sun's polar diſtance and the co-latitude of the Ship.
2. To the log. ſine of half the ſum of this diff. and the Sun's zenith diſtance, add the log. ſine of half the diff. of the ſame arcs, and increaſe the index by 20.
3. Add together the log. ſines of the co-lat. and the polar diſtance.
4. Half the diff. of theſe two ſums is the log. ſine of an arc (half the Sun's merid. dist.) which, being doubled and converted into time, is the apparent time required.

### REMARKS.

1. If the obſervation be made in the forenoon, the time thus found muſt be taken from 24 hours, and the remainder will be the aſtronomical time of the preceding day.

2. The ſame method finds the apparent time by the obſerved altitude of a known Star, writing Star for Sun in the *Formula*. Having found the Star's merid. dist. in time, ſubtract the Sun's *R. A.* in time (corrected for the given meridian and hour, XXIII. R. T. according to the daily variation of the Sun's *R. A.* II. N. A.) from the Star's *R. A.* corrected for the year and month, agreeable to *Ann. Var.* VII. R. T. and increaſed by 24 hours, if neceſſary, the remainder is the time of the Star's culminating: and therefore, by adding or ſubtracting the Star's horary diſtance, as it is to the Weſt or Eaſt of the meridian, the apparent time of obſervation will be obtained.*

3. If the Sun's declination be not of the ſame name with the latitude, that is, both North or both South, then 90 degrees muſt be added to the Sun's declination, for the polar diſtance.

## *METHOD of finding the APPARENT TIME at SEA.*

| | | | ° | ′ | ″ | |
|---|---|---|---|---|---|---|
| **GIVEN** | The Latitude | N. | 34 | 55 | 0 | To find the apparent Time. |
| | Corr. alt. Sun's centre | | 36 | 59 | 39 | |
| | Sun's declination | N. | 22 | 23 | 41 | |

| | ° | ′ | ″ | | |
|---|---|---|---|---|---|
| Sun's zen. dist. | 53 | 0 | 21 | | |
| Sun's polar dist. | 67 | 36 | 29 | *S.* | 9·96596 |
| Co-latitude | 55 | 5 | 0 | *S.* | 9·91381 |
| Diff. | 12 | 31 | 29 | — | 19·87977 |
| Half ſum | 32 | 45 | 55 | *S.* | 9·73335 |
| Half diff. | 20 | 14 | 26 | *S.* | 9·53892 |
| | | | | + | 39·27227 |
| Sun's half mer. dist. | 29 | 48 | 0 | *H.* diff. *S.* | 9·69625 |
| | *H.* | *M.* | *S.* | | |
| App. time from noon | 3 | 58 | 24 | | |
| Or, the preceding day | 20 | 1 | 36 | | |

EXAMPLES

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* But if the approx. time of obſervation be not known, or not to be depended on,—then, add the Star's merid. dist. to its *R. A.* in time, if *W*, or ſubtract it if *E*; and from the ſum, or diff. take the Sun's *R A.* for noon at the given place: the remainder will be approx. time. To this time take out the correction from XXIII. R. T. and ſubtract it from the approx. time, the remainder will be the apparent time of obſervation.

## EXAMPLES for ILLUSTRATION.

### EXAMPLE I.

| | | | ° | ′ | ″ | |
|---|---|---|---|---|---|---|
| GIVEN | The Latitude | *N.* | 16 | 24 | 0 | To find the apparent Time. |
| | Corr. alt. Sun's centre | | 47 | 24 | 0 | |
| | Sun's declination | *S.* | 5 | 47 | 50 | |

| | | ° | ′ | ″ | | |
|---|---|---|---|---|---|---|
| Sun's zenith dist. | | 42 | 36 | 0 | | |
| Sun's declin. + 90 deg. | | 95 | 47 | 50 | | *S.* 9·99777 |
| Co-latitude | . | 73 | 36 | 0 | | *S.* 9·98196 |
| Diff. | | 22 | 11 | 50 | | — 19·97973 |
| Half ſum | | 32 | 23 | 55 | | *S.* 9·72899 |
| Half diff. | | 10 | 12 | 5 | | *S.* 9·24824 |
| | | | | | | + 38·97723 |
| Sun's half mer. dist. | | 18 | 22 | 50 | *H.* diff. | S. 9·49875 |
| | | *H.* | *M.* | *S.* | | |
| App. time from noon | | 2 | 27 | 2 | | |
| Or, the preceding day | | 21 | 32 | 58 | | |

### EXAMPLE II.

1792, March 3, latitude *N.* 45° 37′, long. *W.* 51° 19′, at 2ʰ 55′ *P. M.* per watch, the obſerved altitude of the Sun's lower limb was 24° 47½′, the height of the eye being 16 feet above the ſurface of the ſea. Required the apparent time of obſervation.

### PREPARATION.

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Sun's alt. *L. L.* | | 24 | 47 | 30 |
| Dip | — | 0 | 3 | 49 |
| Refr. | — | 0 | 2 | 3 |
| Par. | + | 0 | 0 | 8 |
| Semidiam. | + | 0 | 16 | 12 |
| Corr. alt. Sun's centre | | 24 | 57 | 28 |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Sun's dec. at noon *N. A.* | | 6 | 25 | 24 |
| Longitude 51° 19′ *W.* | + | 0 | 3 | 12 |
| 2ʰ 55′ *P. M.* | + | 0 | 2 | 48 |
| Red. declin. | *S.* | 6 | 19 | 24 |

| | | | ° | ′ | ″ | |
|---|---|---|---|---|---|---|
| GIVEN | The Latitude | *N.* | 45 | 37 | 0 | To find the appar. Time. |
| | Sun's alt. | | 24 | 57 | 28 | |
| | Sun's declin. | *S.* | 6 | 19 | 24 | |

| | ° | ′ | ″ | | |
|---|---|---|---|---|---|
| Sun's zen. dist. | 65 | 2 | 2 | | |
| Sun's polar dist. | 96 | 19 | 24 | | *S.* 9·99735 |
| Co-lat. | 44 | 23 | 0 | | *S.* 9·84476 |
| Diff. | 51 | 56 | 24 | | — 19·84211 |
| Half ſum | 58 | 29 | 13 | | *S.* 9·93072 |
| Half diff. | 6 | 32 | 49 | | *S.* 9·05696 |
| | | | | | + 38·98767 |
| Sun's half merid. diſt. | 21 | 57 | 26 | H. diff. | *S.* 9·57278 |
| | *H.* | *M.* | *S.* | | |
| Apparent time | 2 | 55 | 39½ | *P. M.* | |

Error of the Watch, 39½ ſec. too ſlow.

## EXAMPLE III.

1800, May 6. Briſtol, latitude 51° 27′ 30″ *N.* longitude 2° 30′ *W.* at $3^h$ 20′ *P. M.* per Watch, regulated to apparent time; the altitude of the Sun's lower limb, taken by the mercurial artificial horizon, was 37° 3′ 32″. Required the true apparent time.

### PREPARATION.

| | ° | ′ | ″ |
|---|---|---|---|
| Sun's alt. *L. L.* | 37 | 3 | 32 |
| Dip | — 0 | 0 | 0 |
| Refr. | — 0 | 1 | 15 |
| Par. | + 0 | 0 | 7 |
| Semidiam. | + 0 | 15 | 53½ |
| Corr. alt. Sun's centre | 37 | 18 | 17½ |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Sun's dec. at noon *N. A.* | | 16 | 32 | 53 |
| Longitude 2° 30′ *W.* | + | 0 | 0 | 7 |
| $3^h$ 20′ *P. M.* | + | 0 | 2 | 25 |
| Red. declin. | *N.* | 16 | 35 | 25 |

GIVEN

| | | | ° ′ ″ | |
|---|---|---|---|---|
| GIVEN | The Latitude | N. | 51 27 30 | To find the appar. Time. |
| | Sun's alt. | | 37 18 17 | |
| | Sun's declin. | N. | 16 35 25 | |

| | ° ′ ″ | |
|---|---|---|
| Sun's zen. diſt. | 52 41 43 | |
| Sun's polar diſt. | 73 24 35 | S. 9·9815337 |
| Co-lat. | 38 32 30 | S. 9·7945463 |
| Diff. | 34 52 5 | — 19·7760800 |
| Half ſum | 43 46 54 | S. 9·8400510 |
| Half diff. | 8 54 49 | S. 9·1901777 |
| | | + 39·0302287 |
| Sun's half merid. diſt. | 25 4 9 | H. diff. 9·6270744 |
| | *H. M. S.* | |
| Apparent time | 3 20 33 *P. M.* | |

Error of the Watch, 33 ſec. too ſlow.

## EXAMPLE IV.

1780, April 14, at 7h 49′ *P. M.* appproximate time, latitude *N.* 48° 56′, long. *W.* 66°; the obſerved altitude of *Aldebaran* was 22° 24½′ *W.* the height of the obſerver's eye above the ſurface of the ſea, 21 feet. Required the true apparent time of obſervation.

## PPEPARATION.

| | | ° ′ ″ | | | *H. M. S.* | |
|---|---|---|---|---|---|---|
| Star's obſ. alt. | | 22 24 30 | Sun's *R. A.* at noon | | 1 33 1 | |
| Refr. | — | 0 2 18 | Long. 66° *W.* | + | 0 0 41 | XXIII. R. T. |
| Dip | — | 0 4 22 | 7h 49′ *P. M.* | + | 0 1 12 | |
| Star's true alt. | | 22 17 50 | Sun's red. *R. A.* | | 1 34 54 | |

| | | |
|---|---|---|
| Star's red. declin. *N.* | 16 3 4 | VII. R. T. |
| Star's red. *R. A.* | 4 23 20 | |

GIVEN

| | | | ° | ′ | ″ | |
|---|---|---|---|---|---|---|
| GIVEN | The Latitude | N. | 48 | 56 | 0 | To find the appar. Time. |
| | Star's alt. | | 22 | 17 | 50 | |
| | Star's declin. | N. | 16 | 3 | 4 | |

| | | ° | ′ | ″ | | |
|---|---|---|---|---|---|---|
| Star's zen. diſt, | | 67 | 42 | 10 | | |
| Star's polar diſt. | | 73 | 56 | 56 | | S. 9·98273 |
| Co-lat. | | 41 | 4 | 0 | | S. 9·81752 |
| Diff. | | 32 | 52 | 56 | | — 19·80025 |
| Half ſum | | 50 | 17 | 33 | | S. 9·88610 |
| Half diff. | | 17 | 24 | 37 | | S. 9·47598 |
| | | | | | | + 39·36208 |
| Star's half merid. diſt. | | 37 | 8 | 48 | H. diff. | S. 9·78092 |
| | | *H.* | *M.* | *S.* | | |
| Star's merid. diſt. | + | 4 | 57 | 10 | | |
| Star's *R. A.* | | 4 | 23 | 20 | | |
| Sun's *R.* A. | | 1 | 34 | 54 | | |
| Add, becauſe W. | + | 2 | 48 | 26 | | |
| Apparent time | | 7 | 45 | 36 | *P. M.* | |

Error of approx. time, 3′ 24″ too forward.

## EXAMPLE V.

### *To find the Apparent Time, and Error of the Watch, the Ship being under way.*

At Sea, 1800, Sept. 25th at noon, Latitude by obſervation, 43° 12′ *N.* Longitude by account, 18° 20′ *W.* In the afternoon, the mean of ſeveral altitudes of the Sun's lower limb, was 22° 51′, and the mean of the times of obſerv. 3h 45′; the height of the eye being 12 feet. The courſe ſince noon was *N. E.* by *E.* 6 knots per hour, and variation 1¼ points weſterly.

Diſt. run, $23^m$; true courſe *N. E. ¼ N.* hence diff. lat. $18\frac{1}{2}^m$, and dep. $13{\cdot}7^m$; therefore, Ship's lat. at mean time of obſerv. is 43° 30′ *N.* and per *Mercator*, 18·5 : 13·7 :: (diff. merid. pts.) 24 : 18, diff. longitude: The Ship's long. at mean time obſerv. 18° 2′ *W.*

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Alt. Sun's L. L. | | 22 | 51 | 0 |
| Dip and refract. | — | | 5 | 32 |
| Parallax | + | | | 8 |
| Semidiam. | + | | 16 | 1 |
| Corr. alt. Sun's cent. | | 23 | 1 | 37 |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Sun's declin. at noon at Gr. | *S.* | 0 | 51 | 15 |
| Long. 18° 2′ *W.* | + | | 1 | 18 |
| $3^h$ 45′ *P. M.* | + | | 3 | 40 |
| Reduced declin. | *S.* | 0 | 56 | 13 |

| | ° | ′ | ″ | | |
|---|---|---|---|---|---|
| Sun's zen. diſt. | 66 | 58 | 23 | | |
| Sun's polar diſt. | 90 | 56 | 13 | | *S.* 9·9999419 |
| Co-lat. | 46 | 48 | 0 | | *S.* 9·8627088 |
| Diff. | 44 | 8 | 13 | | — 19·8626507 |
| Half ſum | 55 | 33 | 8 | | *S.* 9·9162799 |
| Half diff. | 11 | 25 | 5 | | *S.* 9·2965910 |
| | | | | | + 39·2128709 |
| | 28 | 14 | 44<br>8 | *H. D.* | *S.* 9·6751101 |
| App. time at Ship | 3 | 45 | 58 | | |
| Time per Watch | 3 | 45 | 0 | | |
| | | | 58 | ſeconds, Watch too ſlow. | |

PROBLEM

Note.—To obtain the apparent time by the method here given with the greateſt certainty of accuracy, the altitude ſhould be taken when the object changes its altitude the quickeſt; that is, when it is in or near the prime vertical; or, if ſituated within the circle of perpetual apparition, when it is in contact with an azimuth circle; as then, an error in the ſuppoſed latitude is of little conſequence. If the latitude and declination be of contrary names, the meridian diſtance ſhould not be leſs than 25 or 30 degrees at the time of obſervation, nor the altitude under 3 degrees. And the leſs the latitude and declination, and the greater the altitude, the leſs will be the error of apparent time. In general, the

## PROBLEM II.

*To find the Latitude at Sea by two obſerved altitudes of the Sun's lower limb, having given the times of obſervation by the Watch, well regulated to apparent time.*

### PREPARATION.

Find the correct altitudes of the Sun's centre, by ſubtracting the dip and refraction, and adding the parallax and ſemidiameter.

### PRECEPTS.

1. Find the log. of the difference of the nat. ſines of the Sun's greater and leſs correct altitudes.
2. To which add the log. of the difference between the nat. coſine of the Sun's merid. diſt. at the greater altitude and the Radius.
3. From this ſum take the log. of the difference of the nat. coſines of the Sun's meridian diſtances at the two obſerved altitudes.
4. The remainder is the log. of a natural number, which being added to the nat. coſine of the Sun's greater altitude, the ſum will be the nat. ſine of the Sun's meridian altitude. From whence the latitude is determined, as uſual, by the Sun's declination.

METHOD

---

altitudes of the Sun for this purpoſe are beſt taken in the morning, or evening, when they are not more than 18 or 20 degrees, nor leſs than five degrees.

This method of determining the apparent time appears to be the moſt convenient of any for finding the error of a watch at ſea. That by equal altitudes is certainly the moſt accurate for a practical aſtronomer on land, where the obſerver is ſtationary; but at ſea, when a Ship is under way, it is found to be much too troubleſome, and liable to great uncertainty. In either ſituation it cannot be performed by ſolar obſervations with accuracy, without the *correction of equal altitudes*. The common method of taking half the ſum of the times of equal obſerved altitudes for the noon, per watch, is evidently erroneous; and that of adding to, or ſubtracting from, the ſecond altitude, the increaſe or decreaſe of declination during the interval of obſervations, is by no means accurate, as this equation or correction muſt be variable, according to the latitude of the place, as well as to the interval of time, and the daily difference of declination. A table of equation of equal altitudes is conſtructed for this purpoſe. Mr. MACKAY on the longitude is well worth conſulting on this ſubject: and no Navigator, who wiſhes to be maſter of his art, ought to be without this book, and Mr. WALES's Treatiſe on the Method of finding the Longitude at Sea by a Time-keeper.

# METHOD

## *Of finding the Latitude from Two observed Altitudes of the Sun, having the correct times of observation given.*

| | | H. | M. | S. | ° | ′ | ″ | |
|---|---|---|---|---|---|---|---|---|
| GIVEN | Sun's G. alt. | | | | 19 | 40 | 59 | To find the Sun's mer. alt. and the Latitude. |
| | Time from noon *A. M.* | 0 | 30 | 50 | 7 | 42 | 30 | |
| | Sun's L. alt. | | | | 17 | 13 | 4 | |
| | Time from noon *A. M.* | 1 | 30 | 50 | 22 | 42 | 30 | |

| | ° | ′ | ″ | | | *Log.* |
|---|---|---|---|---|---|---|
| Sun's G. alt. | 19 | 40 | 59 | *N. S.* | 33682 | |
| Sun's L. alt. | 17 | 13 | 4 | *N. S.* | 29599 | |
| | | | | Diff. | 4083 | 3·61098 |
| | | | | Rad. | 10·0000 | |
| Sun's merid. dist. *G. A.* | 7 | 42 | 30 | *N. C.* | 99096 | |
| | | | | Diff. | 904 | 2·95617 |
| Sun's merid. dist. *L. A.* | 22 | 42 | 30 | *N. C.* | 92242 | 6·56715 |
| Sun's mer. diſt. *G. A.* | 7 | 42 | 30 | *N. C.* | 99096 | |
| | | | | Diff. | 9854 | 3·83594 |
| | | | | *N. N.* | 539 | 2·73121 |
| Sun's. *G. A.* | 19 | 40 | 59 | *N. S.* | 33682 | |
| Sun's merid. alt. | 20 | 1 | 0 | *N. S.* | 34221 | |
| Sun's declin. {+<br>− | | | | | | |
| Co-latitude | | | | | | |

## EXAMPLE.

Being at ſea, the alt. of the Sun's *L. L.* taken at $11^h$ 29′ *A. M.* was 28° 18′; and at $2^h$ 59 *P. M.* the alt. was found to be 16° 40; the height of the eye being 20 feet, and the Sun's declination 13° 17′ *N.* Required the latitude of the Ship.

PREPARATION.

## PREPARATION.

| 1st. OBSERV. | | ° | ′ | ″ | 2d. OBSERV. | ° | ′ | ″ |
|---|---|---|---|---|---|---|---|---|
| Sun's alt. *L. L.* | | 28 | 2 | 0 | | 16 | 40 | 0 |
| Dip | — | 0 | 4 | 16 | — | 0 | 4 | 16 |
| Refr. | — | 0 | 1 | 46 | — | 0 | 3 | 8 |
| Par. | + | 0 | 0 | 8 | + | 0 | 0 | 8 |
| Sun's semidiam. | + | 0 | 16 | 2 | + | 0 | 16 | 2 |
| Corr. alt. Sun's centre | | 28 | 12 | 8 | | 16 | 48 | 16 |

| | | H. | M. | S. | ° | ′ | ″ | |
|---|---|---|---|---|---|---|---|---|
| GIVEN | Sun's *G. A.* | | | | 28 | 12 | 8 | To find the Latitude. |
| | Time from noon *A. M.* | 0 | 31 | 0 | 7 | 45 | 0 | |
| | Sun's *L. A.* | | | | 16 | 48 | 16 | |
| | Time from noon *P. M.* | 2 | 59 | 0 | 44 | 45 | 0 | |

| | ° | ′ | ″ | | | *Log.* |
|---|---|---|---|---|---|---|
| Sun's *G. A.* | 28 | 12 | 18 | *N. S.* | 47255 | |
| Sun's *L. A.* | 16 | 48 | 16 | *N. S.* | 28931 | |
| | | | | Diff. | 18324 | 4·26302 |
| | | | | Rad. | 100000 | |
| Sun's mer. dist. *G. A.* | 7 | 45 | 0 | *N. C.* | 99087 | |
| | | | | Diff. | 913 | 2·96047 |
| | | | | | | 7·22349 |
| Sun's mer. dist. *L. A.* | 44 | 45 | 0 | *N. C.* | 71019 | |
| Sun's mer. dist. *G. A.* | 7 | 45 | 0 | *N. C.* | 99087 | |
| | | | | Diff. | 28068 | 4·44017 |
| | | | | *N. N.* | 596·1 | 2·77532 |
| Sun's *G. A.* | | | | *N. S.* | 47255 | |
| Sun's mer. alt. | 28 | 35 | 0 | *N. S.* | 47851 | |
| Sun's declin. | 13 | 17 | 0 | | | |
| Lat. of the Ship | 48 | 8 | 0 | *N.* | | |

PROBLEM

A concise FORMULA for finding the TRUE LATITUDE, having the Latitude and Longitude of the Ship by *D. R.* and one observation of the Sun, with the approximate time, or time per Watch, well regulated by previous observations.

| | | ° | ″ | ′ | | | | ° | ″ | ′ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GIVEN. | Lat. *D. R.* | - | - | - | Corrections. | Sun's alt. *L. L.* | | - | - | - | |
| | Long. *D. R.* | - | - | - | | Dip. | — | - | - | - | II. R. T. |
| | Sun's alt. *L. L.* | - | - | - | | Refract. | — | - | - | - | I. R. T. |
| | App. time | - | - | - | | Parallax | + | - | - | - | III. R. T. |
| | | | | | | Sun's semid. | + | - | - | - | III. N. A. |
| | | | | | | Corr. alt. Sun's cent. | | - | - | - | |

| | | ° | ″ | ′ | | | | |
|---|---|---|---|---|---|---|---|---|
| Operation. | Sun's merid. dist. | - | - | - | *N. C.* | - - - - - - | | |
| | | | | | *N. R.* | 1 0 0 0 0 0 | | Log. |
| | | | | | Diff. | - - - - - - | + | - - - - - - - |
| | Sun's red. declin. | - | - | - | | | + | - - - - - - - Log. Cos. |
| | Latitude | - | - | - | | | + | - - - - - - - Log. Cos. |
| | | | | | *N. N.* | + - - - - - - | | - - - - - - - (—20, index |
| | Sun's alt. | - | - | - | *N. S.* | + - - - - - - | | |
| | Sun's merid. alt. | - | - | - | *N. S.* | - - - - - - | Sum. | |
| | Sun's red. declin. (*N. S.*) | - | - | - | | | | |
| | | - | - | - | | | | |
| | | 90 | - | - | | | | |
| | True Latitude | - | - | - | | | | |

N. B. The nearer the observation is made to noon the better; it should not exceed an hour.

A concise FORMULA to find the TRUE LATITUDE at SEA, having given the Latitude and Longitude by *D. R.* two observed altitudes of the Sun, and the interval of time between the observations.

A concise **FORMULA** to find the **TRUE LATITUDE** at **SEA**, having given the Latitude and Longitude by *D. R.* two observed altitudes of the Sun, and the interval of time between the observations.

* * *

° ″ ′

GIVEN { Lat *D. R.* - - - } To find the True Latitude.
Sun's *G.* alt. - - -
Sun's *L.* alt. - - -
Sun's red. declin. *G. A.* - - -
Interval of time - - -

Corrections.

° ″ ′ ° ″ ′
First alt. + - - - Second Alt. + - - -
Dip and Refr. − - - - − - - - I. II. R. T.
Semidiam. + - - - + - - - III. N. A.
True alt. Sun's cent. - - - - - -

Operation.

** Lat. *D. R.* - - - Log. sec. - - - - - -
Sun's red. declin. - - - —— sec. - - - - - -
Log-ratio + - - - - - - (— 20, index.)
Sun's *G. A.* - - - *N. S.* + - - - - -
Sun's *L. A.* - - - *N. S.* + - - - - -
Diff. - - - - - + - - - - - - Comm. Log.
*H. M. S.*
Half elapsed time - - - + - - - - - - }
- - - Mid. time - - - - - - } XVI. R. T.
Time from noon at *G. A.* - - - Diff. Log. rising - - - - - - }
Log. ratio − - - - - - -
*N. N.* - - - - - - - - - - - -
Sun's *G. A.* - - - *N. S.* - - - - - -
Sun's merid. alt. - - - *N. S.* - - - - - - Sum.
Sun's declin. - - -
True Latitude - - -

N. B. If the Lat. resulting differ considerably from the *D. R.* re-compute with this Lat. from **.

# PROBLEM III.

*To find the True Latitude, having the Latitude and Longitude by D. R. one obſervation of the Sun, with the approximate time, or the time per Watch, well regulated by previous obſervations.*

## PREPARATION.

Correct the Sun's altitude for dip, refraction, parallax, and ſemidiam. and reduce the Sun's declin. to the time and place of obſervation.

## PRECEPTS.

1. Find the log. of the difference of the nat. coſines of the Sun's merid. diſtance at the time of obſervation, and the nat. radius.

2. To which add the log. coſines of the Sun's declin. and the latitude by account, ſubtracting 20 from the index of the ſum.

3. To the nat. number of this remainder, add the nat. ſine of the Sun's correct altitude ; the ſum is the nat. ſine of the Sun's meridian altitude. Hence the latitude is found, as uſual, from the Sun's declination.

## METHOD

*Of finding the True Latitude, having the Latitude and Longitude by D. R. and one obſervation of the Sun, with the approximate time.*

| GIVEN | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| Sun's corr. central alt. | | 21 | 55 | 7 | To find the true Latitude. |
| Approx. time of obſerv. *P. M.* 56′ 10″ | | 14 | 2 | 30 | |
| Lat. *D. R.* | *N.* | 47 | 34 | 0 | |
| Sun's red. declin. to long. & A. T. | *S.* | 19 | 30 | 0 | |

| | | ° | ′ | ″ | | | | |
|---|---|---|---|---|---|---|---|---|
| Sun's merid. diſt. | | 14 | 2 | 30 | *N. C.* | 97012 | | |
| | | | | | *N. R.* | 100000 | | |
| | | | | | Diff. | 2988 | | 3·47538 |
| Sun's declin. | | 19 | 30 | 0 | | | Cos. | 9·97435 |
| Lat. | | 47 | 34 | 0 | | | Cos. | 9·82913 |
| | | | | | *N. N.* | 1901 | | 3·27886 |
| Sun's alt. | | 21 | 55 | 7 | *N. S.* | 37326 | | |
| Sun's merid. alt. | | 23 | 6 | 0 | *N. S.* | 39227 | | |
| * Sun's declin. | *S.* | 19 | 30 | 0 | | | | |
| True Latitude | *N.* | 47 | 24 | 30 | | | | |

---

* If great exactneſs be required, the Sun's declination muſt be reduced to the *true* time of obſervation : this, however, in moſt caſes, will be found to be very inconſiderable in the reſult. But it is

## EXAMPLE I.

Being at ſea, 1800, July 20, in latitude *N.* 39° 28′ *D. R.* Sun's declin. 20° 41′ *N*, at 26′ 28″ *P. M.* approximate time, the Sun's alt. *L. L.* was 70° 58′ 30″. Required the latitude of the Ship, the height of the eye being 18 feet.

### PREPARATION.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| Sun's alt. *L. L.* | | 70 | 58 | 30 | |
| Dip | — | 0 | 4 | 6 | |
| Refr. | — | 0 | 0 | 19 | |
| Par. | + | 0 | 0 | 8 | |
| Sun's ſemid. | + | 0 | 15 | 47 | N. A. III. |
| Corr. alt. Sun's centre | | 71 | 10 | 0 | |

By Prob. I. the true time is found to be 6′ 30″ *P. M.*=1° 37′ 30″.

| | ° | ′ | ″ | | | |
|---|---|---|---|---|---|---|
| Sun's merid. diſt. | 1 | 37 | 30 | *N. C.* | 99960 | |
| | | | | *N. R.* | 100000 | |
| | | | | Diff. | 40 | 1·60206 |
| Sun's declin. *A. T.* | 20 | 41 | 0 | | | Cos. 9·97107 |
| Latitude | 39 | 28 | 0 | | | Cos. 9·88761 |
| | | | | *N. N.* | 29 | 1·46074 |
| Sun's alt. | 71 | 10 | 0 | *N. S.* | 94646 | |
| Sun's merid. alt. | 71 | 13 | 0 | *N. S.* | 94675 | |
| Sun's declin. *N.* | 20 | 41 | 0 | | | |
| True Lat. *N.* | 39 | 28 | 0 | | | |

EXAMPLE

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particularly to be noted, that in this method of finding the latitude, it is much better to have the watch *previously* adjuſted to apparent time (*vide* Prob. I. and remark) and then the nearer the obſervation is made to noon the better; it ſhould not exceed an hour. The natural ſines in the computation ſhould alſo be taken to 6 places of figures.

## EXAMPLE II.

At ſea, 1800. January 20, in lat. 50° 40′ *N.* by *D. R.* the Sun's declin. being 20° *S.* at $11^h$ 17′ *A. M.* approx. time, the Sun's correct central altitude was 19° 41′. Required the true latitude of the Ship.

By Prob. I. the true time is $11^h$ 28′ *A. M.* and merid. diſtance 8°.

| | | | ° | ′ | ″ | |
|---|---|---|---|---|---|---|
| GIVEN | Sun's corr. alt. | | 19 | 41 | 0 | To find the Latitude. |
| | True time of obſerv. from noon, *A. M.* | 32′ | 8 | 0 | 0 | |
| | Lat. *D. R.* | *N.* | 50 | 40 | 0 | |
| | Sun's declin. *A. T.* | *S.* | 20 | 0 | 0 | |

| | | ° | ′ | ″ | | | | |
|---|---|---|---|---|---|---|---|---|
| Sun's merid diſt. | | 8 | 0 | 0 | *N. C.* | 99027 | | |
| | | | | | *N. R.* | 100000 | | |
| | | | | | Diff. | 973 | | 2·98811 |
| Sun's declin. *A. T.* | | 20 | 0 | 0 | | | Cos. | 9·97299 |
| Latitude | | 50 | 40 | 0 | | | Cos. | 9·80197 |
| | | | | | *N. N.* | 580 | | 2·76307 |
| Sun's alt. | | 19 | 41 | 0 | *N. S.* | 33682 | | |
| Sun's merid. alt. | | 20 | 2 | 0 | *N. S.* | 34262 | | |
| Declin. | *S.* | 20 | 0 | 0 | | | | |
| Lat. of Ship | *N.* | 49 | 58 | 0 | | | | |

## EXAMPLE III.

1800, Auguſt 9, at Briſtol, lat. *N.* 51° 30′, long. *W.* 2° 35′, by account, took the mean of three altitudes of the Sun's *L. L.* 52° 48′ 58″ by the artificial horizon, allowing for the index-error, &c. of the quadrant; the mean time of obſervation being 49′ 40″ per watch, previouſly adjuſted to apparent time by the tranſit inſtrument. Required the true Latitude.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| Sun's alt. *L. L.* | | 52 | 48 | 58 | |
| Dip | — | 0 | 0 | 0 | |
| Refr. | — | 0 | 0 | 43 | |
| Par. | + | 0 | 0 | 5 | |
| Semid. | + | 0 | 15 | 50 | |
| Corr, alt. Sun's cent. | | 53 | 4 | 10 | |
| Sun's merid. diſt. | | 12 | 25 | 0 | |
| Sun's declin. *T. T.* | | 15 | 52 | 35 | |
| Lat. | | 51 | 30 | 0 | |
| Sun's alt. | | 53 | 4 | 10 | |
| Sun's merid. alt. | | 54 | 25 | 35 | |
| | | 90 | | | |
| Zen. diſt. | | 35 | 34 | 25 | |
| Red. declin. | | 15 | 52 | 35 | |
| True lat, Briſtol | | 51 | 27 | 0 | *N.* |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Sun's dec. noon, N. A. | | 15 | 53 | 20 |
| Long. *W.* | — | 0 | 0 | 7 |
| 49′ 40″ *P. M.* | — | 0 | 0 | 38 |
| Reduced declin. | | 15 | 52 | 35 |

| | | | |
|---|---|---|---|
| *N. C.* | 976610 | | |
| *N. R.* | 1000000 | | |
| Diff. | 23390 | | 4·369030 |
| | | Cos. | 9·983109 |
| | | Cos. | 9·794150 |
| *N. N.* | 14005 | | 4·146289 |
| *N. S.* | 799364 | | |
| *N. S.* | 813369 | | |

## PROBLEM IV.

*To find the True Latitude at Sea, having given the Latitude and Longitude by D. R. two observed altitudes of the Sun, and the interval of time between the obſervations.*

### PREPARATION.

Find the correct altitudes of the Sun's centre at both obſervations, and the declination for the place and the time of the greateſt altitude.

*If the Ship be under way.*

Find the angle between the Ship's courſe and the Sun's bearing at the time of obſerving the leaſt altitude, with which, as a courſe and the diſtance made good (between the obſervations) enter a Traverſe-table, and the *diff. of lat.* will be the correction of the leaſt altitude. If the leaſt altitude be taken *A. M.* the correction will be added or ſubtracted according as the angle between the Ship's courſe and the Sun's bearing be more or leſs than 8 points: And the contrary muſt be obſerved, if the leaſt altitude be *P. M.* The diff. of long. in time is in general too inconſiderable to be taken into the account.

### PRECEPTS.

1. Add together the log. ſecants of the lat. and declin. rejecting 20 from the index, the ſum is the *log. ratio.*

2. To this add the log. of the diff. of the *N. S.* of the two altitudes, and the log. of *half the elapsed time,* XVI. R. T.

3. Find this ſum in the column *midd. time,* XVI. R. T. the diff. between the correſponding time in the table and half the given interval, will be the time from noon when the greateſt altitude was taken.

4. Take the log. to this time from column *Rising,** from which ſubtract the *log. ratio* (1.) the remainder is the logarithm of a natural number, which being added to the nat. ſine of the greateſt altitude, gives the Sun's meridian altitude; from whence and the Sun's declin. the latitude is found as before, correſponding to the time when the greateſt altitude was taken.

### REMARKS.

This method of determining the latitude is to be uſed under certain reſtrictions. 1. The obſervations are beſt taken between *half past nine A. M.* and *half past two P. M.* 2. If both obſervations be *A. M.* or both *P. M.*

---

* The logarithm of the natural verſed ſine of the meridian diſtance in degrees.

the interval of time muſt not be leſs than the Sun's merid. diſt. at the *G.* altitude. 3. If one obſervation be *A. M.* and the other *P. M.* the interval ſhould not exceed *three hours and a half*. And in all caſes, the nearer the *G.* altitude is to noon, the better. Theſe remarks equally apply to Prob. II. *Vide* the Britiſh Mariner's Guide, and the Req. Tables.

## METHOD

### *Of finding the Latitude by Two Solar Altitudes, having given the latitude and longitude by D. R. and the interval of time between the obſervations.*

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| GIVEN | Lat. *D. R.* | *N.* 47 | 34 | 0 | To find the true Latitude. |
| | Sun's *G. A.* | 21 | 55 | 7 | |
| | Sun's *L. A.* | 17 | 39 | 59 | |
| | Sun's red. declin. at *G. A.* | *S.* 19 | 30 | 0 | |
| | Int. of time | 2h | 58′ | 40″ | |

| | ° | ′ | ″ | | | |
|---|---|---|---|---|---|---|
| Lat. *D. R.* | 47 | 34 | 0 | | | Sec. 10·17087 |
| Sun's declin. | 19 | 30 | 0 | | | Sec. 10·02565 |
| | | | | Log. ratio | | 0·19652 |
| Sun's *G. A.* | 21 | 55 | 7 | *N. S.* | 37326 | |
| Sun's *L. A.* | 17 | 39 | 59 | *N. S.* | 30348 | |
| | | | | | 6978 | 3·84373 |
| Half elapſed time | 1h | 29′ | 20″ | XVI. R. T. | | 0·42022 |
| | 0 | 33 | 10 | XVI. R. T. Mid. time | | 4·46047 |
| Time from noon. *G. A.* | 0 | 56 | 10 | XVI. R. T. Log. riſing | | 3·47539 |
| | | | | Log. ratio | | 0·19652 |
| | | | | *N. N.* | 1901 | 3·27887 |
| Sun's *G. A.* | 21 | 55 | 7 | *N. S.* | 37326 | |
| Sun's merid. alt. | 23 | 6 | 0 | *N. S.* | 39227 | |
| Sun's declin. | *S.* 19 | 30 | 0 | | | |
| | 42 | 36 | 0 | | | |
| True Latitude | *N.* 47 | 24 | 0 | | | |

EXAMPLE

## EXAMPLE I.

1800, October 17. In latitude 51° 15′ *N. D. R.* at $0^h$ 32′ *P. M.* pet watch, the altitude of the Sun's lower limb was 28° 32′; and at $2^h$ 41′ *P. M.* it was 19° 25′, the height of the eye being 12 feet. Required the true latitude.

### PREPARATION.

The Sun's reduced declin. Oct. 17, at $0^h$ 32′ *(N. A.)* is 9° 16′ 58″.

| | | ° | ′ | | | ° | ′ |
|---|---|---|---|---|---|---|---|
| Firſt alt. | | 28 | 32 | Second alt, | | 19 | 25 |
| Dip and Refr. | − | 0 | 5 | | − | 0 | 6 |
| Semidiam. | + | 0 | 16 | | + | 0 | 16 |
| True alt, Sun's centre | | 28 | 43 | | | 19 | 35 |

| | | | ° | ′ | |
|---|---|---|---|---|---|
| GIVEN | Lat. *D. R.* | *N.* | 51 | 15 | To find the true Latitude. |
| | Sun's *G. A.* | | 28 | 43 | |
| | Sun's *L. A.* | | 19 | 35 | |
| | Sun's red. declin. at *G. A.* | *S.* | 9 | 17 | |
| | Interv. of time | | $2^h$ | 9′ | |

| | ° | ′ | ″ | | | | |
|---|---|---|---|---|---|---|---|
| Lat. *D. R.* | 51 | 15 | 0 | | | Sec. | 10·20348 |
| Sun's declin. | 9 | 17 | 0 | | | Sec. | 10·00573 |
| | | | | Log. ratio | | + | 0·20921 |
| Sun's *G. A.* | 28 | 43 | 0 | *N. S.* + | 48048 | | |
| Sun's *L. A.* | 19 | 35 | 0 | *N. S.* − | 33518 | | |
| | | | | | 14530 | + | 4·16227 |
| Half elapſed time | $1^h$ | 4′ | 30″ | | | + | 0·55637 |
| | 1 | 40 | 13 | | | Mid. time | 4·92785 |
| Time from noon, *G. A.* | 0 | 35 | 43 | | | Log. riſing | 3·08360 |
| | | | | | | Log. ratio − | 0·20921 |
| | | | | *N. N.* | 749 | | 2·87439 |
| Sun's *G. A.* | 28° | 43′ | | *N. S.* | 48048 | | |
| Sun's *M. A.* | 29 | 13 | | *N. S.* | 48797 | | |
| Sun's declin. *S.* | 9 | 17 | | | | | |
| | 38 | 30 | | | | | |
| Lat. in N. | 51 | 30 | | | | | |

As the lat. here differs conſiderably from the dead reckoning, the work may be eaſily repeated thus :

| | | | |
|---|---|---|---|
| | ° ′ | | |
| Lat. computed | 51 30 | Sec. | 10·20585 |
| Declin. | 9 17 | Sec. | 10·00573 |
| | | Log. ratio | 0·21158 |
| Diff. of *N. S.* | | 14530 | 4·16227 |
| Half elap. time | 1h 4′ 30″ | | 0·55637 |
| | 1 40 50 | Mid. time | 4·93022 |
| Time from N. *G. A.* | 0 36 20 | Log. riſing | 3·09830 |
| | | Log. ratio | 0·21158 |
| | ° ′ ″ | *N. N.* 770 | 2.88672 |
| Sun's *G. A.* | 28 43 0 | *N. S.* 48048 | |
| Sun's *M. A.* | 29 13 20 | *N. S.* 48818 | |
| Sun's declin. *S.* | 9 17 0 | | |
| | 38 30 20 | | |
| True Latitude *N.* | 51 29 40 | | |

## EXAMPLE II.

1800, September 14. At ſea, in latitude N. 38° 12′, and longitude 36¼° *W. D. R.* at 9h 28′ *A. M.* approximate time, the alt. of the Sun's lower limb was 40° 42′, and bearing per compaſs *S. E.* ¼ *S.* And at 11h 16′ *A. M.* the alt. was 53° 11′. The Ship's courſe during the interval was *W.* ½ *N.* at the rate of 9 knots per hour, and the height of the eye 12 feet. Required the true latitude of the Ship at the time of the greateſt altitude.

### PREPARATION.

| | | | |
|---|---|---|---|
| | | | ° ′ ″ |
| Sun's bearing at 1ſt. obſ. | 7½ *P.* | Sun's declin. at noon, N. A. | 3 25 21 |
| Ship's courſe | 4¼ | Long. 36° 15′ *W.* | — 0 2 21 |
| | | 11h 16′ *A. M.* | + 0 11 0 |
| Contained angle | 11¼ | | |
| Supplem. | 4¼ | Reduced declin. | *N.* 3 34 0 |

To courſe 4¼ points and diſt. 16m, the diff. of latitude is 11m nearly.

| | ° ′ | | ° ′ |
|---|---|---|---|
| 1ſt. obſ. alt. | 40 42 | 2d obſ. alt. | 53 11 |
| Dip and refr. | − 0 4 | | − 0 4 |
| Sun's ſemid. | + 0 16 | | + 0 16 |
| Reduct. of alt. | − 0 11 | Corr. alt. | 53 23 |
| Reduced alt. | 40 43 | | |

| | | ° ′ | |
|---|---|---|---|
| GIVEN Lat. *D. R.* | *N.* | 38 12 | To find the true Latitude. |
| Sun's *G. A.* | | 53 23 | |
| Sun's *L. A.* | | 40 43 | |
| Sun's red. declin. at *G. A.* | *N.* | 3 34 | |
| Interv. of time | | 1h 48′ | |

| | ° ′ | | | | |
|---|---|---|---|---|---|
| Lat. *D. R.* | 38 12 | | | Sec. | 10·10466 |
| Sun's declin. *G. A.* | 3 34 | | | Sec. | 10·00084 |
| | | Log. ratio | | | 0·10550 |
| Sun's *G. A.* | 53 23 | *N. S.* | 80264 | | |
| —— *L. A.* | 40 43 | *N. S.* | 65232 | | |
| | | | 15032 | | 4·17702 |
| Half elapſed time | 0h 54′ | | | | 0·63181 |
| | 1 37 | | | Mid. time | 4·91433 |
| Time from noon *G. A.* | 0 43 | | | Log riſing | 3·24437 |
| | | | | Log. ratio | 0·10550 |
| | | *N. N.* | 1376 | | 3·13887 |
| Sun's *G. A.* | 53 23 | *N. S.* | 80264 | | |
| Sun's *M. A.* | 54 43½ | *N. S.* | 81640 | | |
| Sun's declin. *N.* | 3 34 | | | | |
| | 51 9 30 | | | | |
| Lat. in *N.* | 38 50 30 | | | | |

Repeating the operation with this latitude, the reſult is 38° 48′ *N.* the true latitude of the Ship when the greater altitude of the Sun was taken.

# PROBLEM V.

*To find the L~~ong~~atitude at Sea by two equal altitudes of the Sun obſerved the ſame day, and the interval of time between the obſervations.*

## PRECEPTS.

1. The neceſſary corrections being made, add the cos. of half the interval in degrees to the cotang. of the declination, the ſum will be the cotang. of *arc firſt.*

2. Add the ſines of the alt. and of *arc firſt*, to the coſec. of the declin. the ſum will be the cos. of *arc ſecond.*

3. When the declin. and lat. are of the ſame name, the ſum of *arcs* firſt and ſecond will be the latitude; but if of contrary names, their diff. will be the latitude.

## EXAMPLE.

At ſea, 1800, March 7, at $11^{h}$ 10′, and at $12^{h}$ 40′ per watch; the obſerved alt. of the Sun's *L. L.* was the ſame; which being corrected, was 26° 55′, and the Sun's declin. 5° 17′ *S.* Required the latitude.

| | ° | ′ | | | |
|---|---|---|---|---|---|
| Declin. | 5 | 17 | Cot. 1·03398 | | Coſec. 1·03583 |
| Half inter. 45′ | 11 | 15 | Cos. 9·99157 | Alt. 26° 55′ | *S.* 9·65580 |
| Arc firſt | 5 | 23 | Cot. 1·02555 | | *S.* 8·97229 |
| Arc ſecond | 62 | 32 | | | Cos. 9·66392 |
| Latitude | 57 | 9 *N.* | | | |

A NEW

NOTE.—If the Ship makes any conſiderable way between the obſervations, the change of altitude muſt be eſtimated, and the index of the quadrant adjuſted accordingly. The obſerved interval is alſo to be corrected by the change of the Ship's longitude, as in the preceding Problem. If extreme accuracy be required, the half interval ſhould alſo be corrected by the equation of equal altitudes.

# A New and complete FORMULA for computing the LONGITUDE at SEA, by the LUNAR OBSERVATIONS.

| | | H. M. S. | ° ′ ″ | |
|---|---|---|---|---|
| GIVEN | Approxim. time at Ship | - - - | | To find the Ship's True Longitude. |
| | Ship's Lat. *D. R. (N. S.)* | | - - - | |
| | Ship's Long. *D. R. (E. W.)* of Greenwich | | - - - | |
| | Moon's Alt. *L. L.* | | - - - | |
| | S—'s Alt. *L. L.* | | - - - | |
| | Observed Distance of ~~Centres~~ N. L. | | - - - | |
| | Height of the Eye | | - - - | |

Preparation.

| | | ° ′ ″ |
|---|---|---|
| Ship's Long. | | - - - |
| | | 4 |
| In Time {W + / E −} | | - - - |
| Appr. time | + | - - - |
| Time at Greenwich nearly | | - - - |
| Observ. Dist. | + | - - - |
| Sun's semid. | + | - - - |
| Moon's aug. sem. | + | - - - |
| App. Dist. of Centres | | - - - |

| | | ° ′ ″ | |
|---|---|---|---|
| Moon's hor. par. | | - - - | VII. N. A. |
| Moon's semid. | + | - - - | |
| Augment. | + | - - - | IV. R. T. |
| Alt. *L. L.* | + | - - - | |
| Dip. | − | - - - | II. R. T. |
| App. Alt. Moon's centre | | - - - | |
| Sun's semid. | + | - - - | III. N. A. |
| Dip. | − | - - - | II. R. T. |
| Alt. *L. L.* | + | - - - | |
| App. Alt. Sun's centre | | - - - | |

rallax and Refraction.

| | ° ′ ″ | | | ° ′ ″ | |
|---|---|---|---|---|---|
| Corr. of Moon's Alt. with app. alt. centre and Hor. par. | - - -<br>- - - | | + | - - - | VIII. R. T. |
| Corr. of Sun's alt. with app. alt. cent. | - - - | Par. | − | - - - | III. R. T. |
| | | Refr. | + | - - - | I. R. T. |
| If Sun's alt. less than Moon's +<br>If Sun's alt. greater − | | | | - - - | |

Corrections for Parallax and Refr

and Hor. par. - - - + - - - VIII. R. T.
Corr. of Sun's alt. with app. alt. cent. - - - { Par. — - - - III. R. T.
{ Refr. + - - - I. R. T.

If Sun's alt. less than Moon's + }
If Sun's alt. greater — } - - -

° ′ ″
Sun's app. alt. - - -
Moon's app. alt. - - -

Diff. of app. altitudes + - - -

Diff. of true altitudes - - -

To find the true Distance.

° ′ ″
Diff. true altitudes - - - *N. C.* - - - - -

Diff. app. altitudes - - - *N. C.* - - - - -
App. dist. of centres - - - *N. C.* - - - - -

*Log.*
Diff. - - - - - - - - - - -
Moon's app. alt. and Hor. par. - - - - - - IX. R. T.

*N. N.* — - - - - - - - - - - -

True dist. of the centres *N. C.* - - - -

To find the true Time at Greenwich, N. A. VIII. &c.

° ′ ″ ° ′ ″
Given dist. - - -
Preceding dist. at - - - Diff. - - - *P. L.* - - - - }
Following dist. at - - - Diff. - - - *P. L.* - - - - } XV. R. T.
*H. M. S.*
Excess - - - *P. L.* - - - - }
Preceding time + - - -

True time at Greenwich - - -
Hence the *computed* time at Ship (if necessary) - - -

4) - - - Diff.

True Longitude of Ship - - - { E. if Greenw. time be — .
{ W. if Greenw. time be + .

# A NEW AND CONCISE
# METHOD
# OF
# FINDING THE LONGITUDE AT SEA,
# BY THE
# LUNAR OBSERVATIONS.

## PREPARATION.

1. Multiply the Ship's longitude *D. R.* by 4; and if *W.* add the product to, but if *E.* ſubtract it from, the approx. time at the Ship, and the reſult will be the time at the meridian of Greenwich nearly,

2. To this time find the moon's ſemidiam. and horizontal parallax, p. VIII. N. A. alſo the Sun's ſemidiam. for the given day, p. III. N. A. and augment the Moon's ſemidiam. by the *seconds* in IV. R. T. correſponding to her obſerved altitude: And to the obſerved diſtance add the correct ſemidiameters.

3. Correct the obſerved altitudes by ſubtracting the dip of the horizon, according to the height of the obſerver's eye, and adding the ſemidiameters; and the *apparent distance* and altitudes of the centres of the Sun and Moon will be obtained.

## *To find the True Distance of the Centres of the Sun and Moon.*

Take out the correction of the Moon's alt. VIII. R. T. to which add the difference between the refraction and parallax of the Sun in altitude, I. III. R. T. Then, add this ſum to, or ſubtract it from, the difference of the apparent altitudes of the centres, according as the Sun is lower or higher than the Moon, and it will give the difference of the true altitudes.

### *If the observed distance be less than* 90 *degrees,*

From the nat. coſine of the difference of the true altitudes, ſubtract the natural number correſponding to the ſum of the logarithms of the diff. of the nat. coſines of the apparent altitudes, and the apparent diſtance of the centres, and the logarithm anſwering to the Moon's appar. alt. and horiz. parallax, IX. R. T. the remainder will be the nat. coſine of the true diſtance.

### *If the observed distance be more than* 90 *degrees,*

Add together the coſine-ſupp. of the obſerved diſtance and the coſine of the diff. of the apparent altitudes, and to the log. of this ſum, add the log. anſwering to the Moon's app. alt. and horiz. parallax, IX. R. T. Then, from the nat. numb. correſponding to the ſum of theſe logarithms, ſubtract the nat. coſine of the difference of the true altitudes, and the remainder will be the nat. coſine-ſupp. of the true diſtance. Or, proceeding as in the former caſe, *add* the *N. C.* of the apparent diſtance (the coſine of the ſupp. being negative), and the *difference* between the *N. N.* and the *N. C.* of the diff. of true altitudes, will give the ſame reſult.

METHOD,

## METHOD, *in Case* I.*

| | | ° | ′ | ″ |
|---|---|---|---|---|
| GIVEN | The app. diſtance between the centres of the Sun and Moon | 81 | 23 | 38 |
| | The app. alt. of the Sun's centre | 27 | 43 | 0 |
| | The app. alt. of the Moon's centre | 48 | 22 | 0 |
| | The Moon's horiz. parallax | 0 | 58 | 45 |

Required the true diſtance.

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Correct. Moon's alt. (48° 22′) VIII. R. T. | | 0 | 38 | 26 |
| Corr. Sun's alt. | Par. III. R. T. | − 0 | 0 | 8 |
| | Refr. I. R. T. | + 0 | 1 | 48 |
| | | 0 | 40 | 6 |
| Diff. app. altitudes (Sun lower) | | + 20 | 39 | 0 |
| Diff. true altitudes | | 21 | 19 | 6 |

| | ° | ′ | ″ | | | |
|---|---|---|---|---|---|---|
| Diff. T. A. | 21 | 19 | 6 | *N. C.* | 93158 | |
| Diff. A. A. | 20 | 39 | 0 | *N. C.* | 93575 | |
| App. Diſt. | 81 | 23 | 38 | *N. C.* | 14964 | |
| | | | | Diff. | 78611 | 4·89548 |
| Moon's app. alt. and hor. par. IX. *R.* T. | | | | | | 9·99462 |
| | | | | *N. N.* | 77644 | 4·89010 |
| True diſtance 81° 4′ 31″ | | | | *N. C.* | 15514 | |

METHOD

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* See the ſame Example in Mackay on the Longitude, p. 112.

## METHOD, *in Case* 2.*

| | | | ° | ′ | ″ | |
|---|---|---|---|---|---|---|
| GIVEN | Moon's apt. alt. | | 22 | 15 | 0 | Required the true distance. |
| | Sun's app. alt. | | 21 | 35 | 0 | |
| | —— app. diſt. | | 119 | 20 | 34 | |
| | Moon's hor. par. | | 0 | 58 | 0 | |
| | Corr. Moon's alt. | | 0 | 51 | 22 | |
| Corr. | Sun's alt. par. | — | 0 | 0 | 8 | |
| | Refract. | + | 0 | 2 | 24 | |
| | | | 0 | 53 | 38 | |
| | Diff. app. altitudes (Sun lower) | + | 0 | 40 | 0 | |
| | Diff. true altitudes | | 1 | 33 | 38 | |

| | ° | ′ | ″ | | | |
|---|---|---|---|---|---|---|
| Supp. app. diſt. | 60 | 39 | 26 | *N. C.* | 490038 | |
| Diff. app. alt. | 0 | 40 | 0 | *N. C.* | 999932 | |
| | | | | Sum | 1489970 | 6·173177 |
| Moon's app. alt. and hor. par. | | | | IX. R. T. | | 9·997409 |
| | | | | *N. N.* | 1481115 | 6·170586 |
| Diff. true alt. | | | | *N. C.* | 999630 | |
| True diſt. 118° 46′ 56″ | | | | *N. C.* Supp. | 481485 | |

Or thus:

| | ° | ′ | ″ | | | |
|---|---|---|---|---|---|---|
| Diff. *T. A.* | 1 | 33 | 38 | *N. C.* | 999630 | |
| Diff. *A. A.* | 0 | 40 | 0 | *N. C.* | 999932 | |
| App. diſt. | 119 | 20 | 34 | *N. C.* | 490038 | |
| | | | | Sum | 1489970 | 6·173177 |
| Moon's app. alt. and hor. par. | | | | | | 9·997409 |
| | | | | *N. N.* | 1481115 | 6·170586 |
| True diſt. 118° 46′ 56″ | | | | *N. C.* Supp. | 481485 | |

Having

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* See this Example in Kelly on the Longitude, p. 208.

### *Having the True Distance of the centres of the Sun and Moon, or of the Moon and a Star, to find the corresponding time at the Royal Observatory, Greenwich.*

Look for the diſtance in either of the pages VIII, IX, X, XI, of the Month N. A. oppoſite the given day; and if it be found there, the time is ſeen at the top of the page. But as this ſeldom happens, find the two neareſt diſtances, one greater and the other leſs than the given diſtance, and take the difference: Take alſo the difference between the given and preceding diſtances. Subtract the prop. log. of the former from that of the latter, and the remainder will be the prop. log. of the exceſs of time above that correſponding to the preceding diſtance.

## EXAMPLE.

1800, July 15, the true diſtance between the centres of the Sun and Moon was 67° 10′ 20″. Required the apparent time at Greenwich.

| | ° | ′ | ″ | | ° | ′ | ″ | | |
|---|---|---|---|---|---|---|---|---|---|
| Given diſt. | 67 | 10 | 20 | | | | | | |
| Diſt. at VI$^{h}$ | 68 | 1 | 13 | Diff. | 0 | 50 | 53 | P. L. | 5487 |
| Diſt. at IX$^{h}$ | 66 | 39 | 45 | Diff. | 1 | 21 | 28 | P. L. | 3443 |
| | Exceſs | | | | 1 | 52 | 26 | P. L. | 2044 |
| | Preceding time | | | | 6 | 0 | 0 | | |
| App. time at Greenwich | | | | | 7 | 52 | 26 | P. M. | |

Laſtly, compute the app. time at the Ship, with the Sun's corr. alt. reduced declin. to the time at Greenwich, and the latitude; the difference between this and the time at Greenwich, will give the Longitude of the Ship in time. If the watch be previouſly adjuſted to app. time, and its rate known, this is unneceſſary.

## EXAMPLE I.

| | | H. | M. | S. | | |
|---|---|---|---|---|---|---|
| GIVEN | True time at Ship, | 5 | 36 | 0 | *P. M.* | 1796, May 31. |
| | Ship's long. *D. R.* | 23 | 0 | 0 | *E.* | To find the |
| | Moon's obſ. alt. *L. L.* | 23 | 48 | 15 | | True Longitude. |
| | Sun's obſ. alt. *L. L* | 31 | 48 | 15 | | |
| | App. diſt. neareſt *L.*'s | 68 | 10 | 24 | | |

| | | ° | ' | " |
|---|---|---|---|---|
| Ship's long. | | 23 | 0 | 0 |
| | | | | 4 |
| In time *E.* | — | 1h | 32' | |
| Time at Ship | + | 5 | 36 | |
| Time at Gr. nearly | | 4 | 4 | *P. M.* |

| | | ° | ' | " |
|---|---|---|---|---|
| Moon's hor. par. | | 0 | 58 | 10 |
| Moon's ſemid. | + | 0 | 15 | 51 |
| Augm. | + | 0 | 0 | 7 |
| Alt. *L. L.* | + | 23 | 48 | 15 |
| Dip | — | 0 | 4 | 3 |
| App. alt. Moon's cent. | | 24 | 0 | 10 |

| | | ° | ' | " |
|---|---|---|---|---|
| Obſ. diſt. | | 68 | 10 | 24 |
| Sun's ſemid. | + | 0 | 15 | 49 |
| Moon's aug. ſem. | + | 0 | 15 | 58 |
| App. diſt. centres | | 68 | 42 | 11 |

| | | ° | ' | " |
|---|---|---|---|---|
| Sun's ſemid. | + | 0 | 15 | 49 |
| Dip | — | 0 | 4 | 3 |
| Alt. *L. L.* | + | 31 | 48 | 15 |
| App. alt. Sun's cent. | | 32 | 0 | 1 |

Corr. Moon's alt.

| | ° | ' | " | | | ° | ' | " |
|---|---|---|---|---|---|---|---|---|
| With app. alt. cent. | 24 | 0 | 10 | } | + | 0 | 51 | 1 |
| And hor. par. | 0 | 58 | 10 | | | | | |

Corr. Sun's alt.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| With app, alt. cent. | 32 | 0 | 1 | Par. | — | 0 | 0 | 8 |
| | | | | Refr. | + | 0 | 1 | 31 |
| | | | | Sun's alt. greater | — | 0 | 52 | 24 |

Sun's

| | | | | |
|---|---|---|---|---|
| | ° ′ ″ | | | |
| Sun's app. alt. | 32 0 1 | | | |
| Moon's app. alt. | 24 0 10 | | | |
| Diff. of app. alts. | | | | + 7 59 51 |
| Diff. of true alts. | | | | 7 7 27 |
| Diff. of true altitudes | 7 7 27 | *N. C.* | 99298 | |
| Diff. app. alts. | 7 59 51 | *N. C.* | 99027 | |
| App. dist. centres | 68 42 11 | *N. C.* | 36320 | |
| | | Diff. | 62707 | 4·79732 |
| Moon's app. alt. and hor. par. IX. R. T. | | | | 9·99719 |
| | | *N. N.* — | 62303 | 4·79451 |
| True dist. of the centres | 68 19 50 | *N. C.* | 36925 Diff. | |

| | | | | | |
|---|---|---|---|---|---|
| | ° ′ ″ | | ° ′ ″ | | |
| Given dist. | 68 19 50 | | | | |
| Dist. at III^h | 68 57 44 | Diff. | 0 37 54 | *P. L.* | 6766 |
| Dist. at VI^h | 67 23 15 | Diff. | 1 34 29 | *P. L.* | 2799 |
| | Exceſs | | 1 12 12 | *P. L.* | 3967 |
| | Preceding time | | 3 | | |
| | App. time at Greenwich | | 4 12 12 | *P. M.* | |
| | Time at Ship | | 5 36 0 | | |
| | | 4) | 1 23 48 | | |
| | True long. of the Ship | | 20° 57′ | *E.* of Greenwich. | |

EXAMPLE

NOTE.—As the reſult in this Example does not entirely agree with that in H. Moore's Practical Navigator, p. 244, it may not be improper to remark here, that in computing the true diſtance with logarithms to 4 places of figures only (beſides the index), the reſult may err ſome minutes from the truth; but with 5 places of figures, we may always depend on the anſwer within a few ſeconds; particularly if the obſerved diſtance be not leſs than 14°. If greater accuracy be required, 6 or 7 places of figures in the logarithms will be found requiſite.

When the diſtance is put down to *seconds*, and the common log. tables are uſed, the ſeconds may be omitted till the operation be finiſhed, which may then be added to the computed diſtance. This will ſhorten the work conſiderably.

## EXAMPLE II.

1800, May 19. At ſea, lat. N. 34° 53′, long. *E.* 165 *D. R.* at 6h 30′ *A. M.* approx. time; the alt. of the Sun's lower limb was 14° 20′, and of the Moon's lower limb 42°; and the diſtance between the neareſt limbs 41° 29′, the height of the eye being 12 feet. Required the true longitude.

| | | |
|---|---|---|
| Ship's long. | | 165 |
| | | 4 |
| In time *E.* | — | 11h 0′ |
| Time at Ship | | 18 30 |
| Time at Gr. nearly | | 7 30 *P. M.* |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Moon's hor. par. | | 0 | 54 | 47 |
| Moon's ſemid. | + | 0 | 14 | 56 |
| Augm. | + | 0 | 0 | 10 |
| Alt. *L. L.* | + | 42 | 0 | 0 |
| Dip | — | 0 | 3 | 18 |
| App. alt. M.'s cent. | | 42 | 11 | 48 |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Obſerved diſt. | | 41 | 29 | 0 |
| Sun's ſemidiam. | + | 0 | 15 | 51 |
| Moon's aug. ſem. | + | 0 | 15 | 6 |
| App. diſt. centres | | 41 | 59 | 57 |

| | | | | |
|---|---|---|---|---|
| Sun's ſemid. | + | 0 | 15 | 51 |
| Alt. *L. L.* | + | 14 | 20 | 0 |
| Dip | — | 0 | 3 | 18 |
| App. alt. Sun's cent. | | 14 | 32 | 33 |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Corr. of Moon's alt. (to 42° 11′ 48″, and par. 54′ 47″) | + | 0 | 39 | 33 |
| Corr. Sun's alt. { Parallax | — | 0 | 0 | 8 |
| Corr. Sun's alt. { Refract. | + | 0 | 3 | 43 |
| Sun's alt. leaſt | + | 0 | 43 | |

| | ° | ′ | ″ |
|---|---|---|---|
| Sun's app. alt. | 14 | 32 | 33 |
| Moon's app. alt. | 42 | 11 | 48 |

Diff.

| | ° | ' | " |
|---|---|---|---|
| Diff. app. alts. | + 27 | 39 | 15 |
| Diff. true altitudes | 28 | 22 | 23 |

| | ° | ' | " | | | |
|---|---|---|---|---|---|---|
| Diff. true alts. | 28 | 22 | 23 | *N. C.* | 879872 | |
| Diff. app. alts. | 27 | 39 | 15 | *N. C.* | 885765 | |
| Appar. dist. | 42 | 0 | 0 | *N. C.* | 743145 | |
| | | | | Diff. | 142620 | 5·154180 |
| Moon's alt. and hor. par. IX. R. T. | | | | | | 9·995540 |
| | | | | *N. N.* — | 141163 | 5·149720 |
| True distance | 42 | 22 | 42 | *N. C.* | 738709 Diff. | |

### To find the true time at Greenwich.

| | ° | ' | " | | ° | ' | " | | |
|---|---|---|---|---|---|---|---|---|---|
| Given dist. | 42 | 22 | 42 | | | | | | |
| Dist. at VI. N. A. | 43 | 3 | 14 | Diff. | 0 | 40 | 32 | *P. L.* | 6474 |
| Dist. at IX. | 41 | 40 | 6 | Diff. | 1 | 23 | 8 | *P. L.* | 3355 |
| | | | | Excess | 1 | 27 | 46 | *P. L.* | 3119 |
| | | | | Preceding time | 6 | | | | |
| Appar. time at Greenwich | | | | | 7 | 27 | 46 | *P. M.* | |

## To find the correct time at Ship.

The Sun's declin. to the app. time at Greenwich, N. A. is 19° 50′ 38″.

| | | ° | ′ | ″ | | |
|---|---|---|---|---|---|---|
| Sun's app. alt. | | 14 | 32 | 33 | | |
| Refract. | — | 0 | 3 | 38 | | |
| Par. | + | 0 | 0 | 8 | | |
| Sun's alt. corr. | | 14 | 29 | 3 | | |
| | | 90 | | | | |
| Sun's zen. diſt. | | 75 | 31 | 0 | | |
| Polar diſt. | | 70 | 9 | 22 | | *S.* 9·9734601 |
| Co-lat. | | 55 | 7 | 0 | | *S.* 9·9139824 |
| Diff. | | 15 | 2 | 22 | — | 19·8874425 |
| Half ſum | | 45 | 16 | 41 | | *S.* 9·8515824 |
| Half diff. | | 30 | 14 | 19 | | *S.* 9.7020911 |
| | | | | | + | 39·5536735 |
| Sun's half merid. diſt. | | 42 | 55 | 4 | | *S.* 9·8331155 |
| True time from noon | | 5h | 21′ | 53″ | | |
| Or | | 6 | 38 | 7 | | *A. M.* true time at Ship. |

Hence the true long. is 167° 35′ 15″ *E.*

EXAMPLE

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Note.—It is neceſſary to obſerve, that in deducing the true time at the place of obſervation from the obſerved altitude of the Sun or Star, ſuch poſitions of them ſhould be choſen when they are not leſs than 30 or 25 deg. from the meridian, as a ſmall error in the altitude of an object near the meridian, may produce a conſiderable error in the apparent time. (See note, p. 13.)

## EXAMPLE III.

Being in the Briſtol Channel, off Arlope Point, lat 51° 27′ *N.* long. 2° 30′ *W.* per Chart, 1800, April 26, at 8h 50′ *P. M.* per watch, made the following obſervations,—the diſt. of the Moon's neareſt limb from *Pollux*, 43° 19′ 45″; the alt. of the Moon's lower limb 10° 33′, and of the Star 42° 23′; the height of the eye being 10 feet. Required the true longitude.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| Ship's long. | | 0 | 2 | 30 | |
| | | | | 4 | |
| In time *W.* | + | 0 | 10 | 0 | |
| Time at Ship | | 8 | 50 | 0 | |
| Time at Gr. nearly | | 9 | 0 | 0 | *P. M.* |
| Obſerved diſt. | | 43 | 19 | 45 | |
| Moon's aug. ſem. | | 0 | 14 | 48 | |
| App. diſt. of Moon's cent. and Star | | 43 | 34 | 33 | |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Moon's hor. par. | | 0 | 54 | 8 |
| Moon's ſemid. | | 0 | 14 | 45 |
| Augm. | + | 0 | 0 | 3 |
| Alt. *L. L.* | + | 10 | 33 | 0 |
| Dip | — | 0 | 3 | 0 |
| App. alt. Moon's cent. | | 10 | 44 | 48 |
| Star's obſ. alt. | | 42 | 23 | 0 |
| Dip | — | 0 | 3 | 0 |
| Star's app. alt. | | 42 | 20 | 0 |

---

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Corr. Moon's alt. (10° 44′ 48″, par 54′ 8″) | + | 0 | 48 | 17 |
| Star's refract. | + | 0 | 1 | 2 |
| Star's alt. *G.* | — | 0 | 49 | 19 |

| | ° | ′ | ″ |
|---|---|---|---|
| Star's app. alt. | 42 | 20 | 0 |
| Moon's app. alt. | 10 | 44 | 48 |

| | | | | |
|---|---|---|---|---|
| Diff. app. alt. | + | 31 | 35 | 12 |
| Diff. true alts. | | 30 | 45 | 53 |

Diff.

|  | ° | ′ | ″ |  |  |  |
|---|---|---|---|---|---|---|
| Diff. of true altitudes | 30 | 45 | 53 | *N.C.* | 859275 |  |
| Diff. app. alts. | 31 | 35 | 12 | *N.C.* | 851849 |  |
| App. diſtance of cent. | 43 | 34 | 33 | *N.C.* | 724463 |  |
|  |  |  |  | Diff. | 127386 | 5·105122 |
| Moon's corr. IX. R. T. |  |  |  |  |  | 9·998917 |
|  |  |  |  | *N. N.* | 127070 | 5·104039 |
| True diſt. | 42 | 55 | 42 | *N.C.* | 732205 | Diff. |

To find the true time at Greenwich.

|  | ° | ′ | ″ |  | ° | ′ | ″ |  |
|---|---|---|---|---|---|---|---|---|
| Given diſt. | 42 | 55 | 42 |  |  |  |  |  |
| Diſt. at IX$^{h}$ | 43 | 3 | 56 | Diff. | 0 | 8 | 14 | *P.L.* 1·3397 |
| Diſt. at XII$^{h}$ | 41 | 35 | 23 | Diff. | 1 | 28 | 33 | *P.L.* 3081 |
|  |  |  |  | Exceſs | 0 | 16 | 44 | *P.L.* 1·0316 |
|  |  |  |  | Preceding time | 9 | 0 | 0 |  |
| App. time at Greenwich |  |  |  |  | 9 | 16 | 44 |  |

To find the true time at Ship.

| | | ° | ′ | ″ | | | h | ′ | ″ |
|---|---|---|---|---|---|---|---|---|---|
| Pollux's declin. 1780. VII. R. T. | | 28 | 32 | 24 | *R. A.* | | 7 | 31 | 49 |
| Var. 20^y 4^mo. | — | 0 | 2 | 38 | | + | 0 | 1 | 15 |
| Star's Corr. declin. | *N.* | 28 | 29 | 46 | Cor. *R. A.* | | 7 | 33 | 4 |

Sun's corr. *R. A.* 2^h 16′ 5″, III. N. A. Star's alt.—refr. 42° 18′ 58″.

| | | ° | ′ | ″ | | |
|---|---|---|---|---|---|---|
| Star's zen. diſt. | | 47 | 41 | 2 | | |
| — polar diſt. | | 61 | 30 | 14 | | *S.* 9·943914 |
| Co-lat. | | 38 | 33 | 0 | | *S.* 9·794150 |
| Diff. | | 22 | 57 | 14 | — | 19·738064 |
| H. ſum | | 35 | 19 | 8 | | *S.* 9·761999 |
| H. diff. | | 12 | 21 | 54 | | *S.* 9·330695 |
| | | | | | + | 39·092694 |
| Star's merid. diſt. *W.* | | 56 | 48 | 26 | | *S.* 9·677315 |
| Or, in time | + | 3^h | 47′ | 13″ | | |
| Star's ſouthing | | 5 | 16 | 59 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Star's *R. A.* | 7^h | 32′ | 4″ |
| | | | | Sun's *R. A.* | 2 | 16 | 5 |
| True time at Ship | 9 | 4 | 12 *P. M.* | | | | |
| Time at Greenwich | 9 | 16 | 44 | Time of Star ſo. | 5 | 16 | 59 |
| Diff. of long. in time | 0 | 12 | 32 | | | | |

Hence 3° 8′ *W.* is the true longitude of the place of obſervation.

Error of the watch 14′ 12″ too ſlow. Error of the chart in long. 38′ eaſterly.

EXAMPLE

## EXAMPLE IV.

At Briſtol, lat. 51° 27′ *N.* long. by account, 2° 35′ *W.* 1800, July 1, took the mean of ſeveral obſervations,—mean time 6h 25′ 10″ *P. M.* alt. Sun's lower limb, 13° 56′ 10″; alt. Moon's lower limb, 24° 31′ 40″; and the diſt. of the neareſt limbs, 112° 42′ 47″. The altitudes being taken by the artificial mercurial horizon, and the errors of the ſextants allowed for in each obſervation.

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Ship's long. | | 0 | 2 | 35 *W.* |
| | | | | 4 |
| | | 0 | 10 | 20 |
| Approx. time | + | 6 | 25 | 10 |
| Time at Gr. nearly | | 6 | 35 | 30 *P. M.* |
| Obſerved diſt. | | 112 | 42 | 47 |
| Sun's ſem. | + | 0 | 15 | 47 |
| Moon's aug. ſem. | + | 0 | 16 | 22 |
| App. diſt. centres | | 113 | 14 | 56 |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| Moon's hor. par. | | 0 | 59 | 39 |
| Moon's ſemid. | | 0 | 16 | 15 |
| Augm, | + | 0 | 0 | 7 |
| Alt. *L. L.* | + | 24 | 31 | 40 |
| Dip | | 0 | 0 | 0 |
| App. alt. Moon's cent. | | 24 | 48 | 2 |
| Sun's ſemid. | | 0 | 15 | 47 |
| Alt. *L. L.* | + | 13 | 56 | 10 |
| Dip | | 0 | 0 | 0 |
| App. alt. Sun's cent. | | 14 | 11 | 57 |

| | | | | |
|---|---|---|---|---|
| Corr. Moon's alt. IX. R. T. | + | 0 | 52 | 9 |
| Corr. Sun's alt. Par. | − | 0 | 0 | 8 |
| Refr. | + | 0 | 3 | 42 |
| Sun's alt. leaſt | + | 0 | 55 | 43 |

| | ° | ′ | ″ |
|---|---|---|---|
| Sun's app. alt. | 14 | 11 | 57 |
| Moon's app. alt. | 24 | 48 | 2 |
| Diff. app. alts. | 10 | 36 | 5 |
| Diff. true altitudes | 11 | 31 | 48 |

| | ° | ′ | ″ | | | |
|---|---|---|---|---|---|---|
| Supp. app. diſt. | 66 | 45 | 4 | *N. C.* | 394577 | |
| Diff. app. alt. | 10 | 36 | 5 | *N. C.* | 982931 | |
| | | | | Sum | 1377508 | 6·139113 |
| Moon's corr. IX. R. T. | | | | | | 9·997018 |
| | | | | *N. N.* | 1368140 | 6·136131 |
| Diff. true alt. | 11 | 31 | 48 | *N. C.* | 979820 | |
| True diſt. 112° 51′ | | | | *N. C.* Supp. | 388320 | Diff. |

| | ° | ′ | ″ | | ° | ′ | ″ | | |
|---|---|---|---|---|---|---|---|---|---|
| Given diſt. | 112 | 51 | 0 | | | | | | |
| Diſt. at VI$^{h}$ | 112 | 31 | 22 | Diff. | 0 | 19 | 38 | *P. L.* | 9623 |
| Diſt. at IX$^{h}$ | 114 | 10 | 57 | Diff. | 1 | 39 | 35 | *P. L.* | 2571 |
| | | | | Exceſs | 0 | 35 | 29 | *P. L.* | 7052 |
| | | | | Preceding time | 6 | 0 | 0 | | |
| App. time at Greenwich | | | | | 6 | 35 | 29 | *P. M.* | |

Which differing only by 1 ſecond from the time inferred at Greenwich by the given longitude, ſhews the correctneſs of the watches (which had been previouſly adjuſted to apparent time, and the errors of rates allowed for in the intervals), and the accuracy of the obſervations.

This may be alſo eaſily aſcertained as before from the Sun's (mean) altitude.

The Sun's corr. declin. is 23° 7′ 21″ N. A.

The Sun's alt. corrected for parallax and refr. 14° 8′ 23″.

| | ° | ′ | ″ | |
|---|---|---|---|---|
| Sun's zen. diſt. | 75 | 51 | 37 | |
| —— Polar diſt. | 66 | 52 | 39 | S. 9·963627 |
| Colat. | 38 | 33 | 0 | S. 9·794626 |
| Diff. | 28 | 19 | 39 | — 19·758253 |
| H. ſum | 52 | 5 | 38 | S. 9·897087 |
| H. diff. | 23 | 45 | 59 | S. 9·605318 |
| | | | | + 39·502405 |
| | 48 | 8 | 50 | S. 9·872076 |
| | | | 8 | |
| True time at Briſtol | $6^{h}$ | 25′ | 10⅔″ | |
| True time at Gr. | 6 | 35 | 29 | |
| Diff. of long. in time | 0 | 10 | 18⅓, or 2° 34½′ *W.* | |

Hence the latitude and longitude of Fort-Royal, St. Michael's Hill, (the place where the obſervations were taken), in the City of Briſtol, may be put down with certainty to half a minute, ——

Lat. *N.* 51° 27′, long. *W.* of the Royal Obſervatory, 2° 34′.

*A plain*

# *A plain and concise* PROJECTION *for clearing the Lunar diſtances from the effects of* PARALLAX *and* REFRACTION, *performed by Two Lines only, on the common Navigation Rules, ſufficiently accurate for all the purpoſes of Navigation.*

## PROJECTION.—Fig. 1.

On a line *HD* and centre *C*, taken at pleaſure, with the radius of a line of chords (60), deſcribe a ſemicircle *HZD*, making *CZ* perpend. *HD*. Set off *Zz* the chord of the *apparent* diſtance, and draw *Cz*, and perpend. thereto *CE*. Set off *DL*, the chord of the Moon's app. alt. and *EP*. the chord of the Sun's (or Star's) altitude. Draw *LM* parallel to *HD*, and *PS* par. to *CE*. Then will *MN*, meaſured on the ſame line of chords, (calling every degree a minute) be the FIRST correction of the app. diſtance, — ſubtractive when it falls on the ſame ſide of *CZ* with *(S)* the Sun or Star, but additive when it falls on the contrary ſide.

When *MN* is —, the extent of the compaſſes from 63 on the *line of numbers* to the number expreſſing the minutes in *MN*, will reach from the number expreſſing the difference in minutes between the Moon's given hor. par. and the *greateſt* par. (62 min.) to a fourth number, which is the parallactic correction of the appar. diſtance. If *MN* be +, the compaſſes muſt be extended from 54 to the minutes in *MN*, and this extent applied from the number expreſſing the difference between the given hor. parallax and the *leaſt* parallax (53 min.) will give the correction. Or this correction may be immediately found by the ſlide, or by the pen. This ſecond corr. is always additive to the appar. diſtance.

When *PS* paſſes through *M*, *MN* vaniſhes, and there is no ſenſible correction; which circumſtance evidently takes place when the coſine of the apparent diſtance is to ſine of the Sun's (Star's) altitude, as rad. is to ſine of the Moon's altitude: For in the triang. *CMS*, cos. ang. *C* : *CS* :: rad. : *CM*.

## GENERAL REMARKS.

1. When the obſerved diſtance is greater than the Sun's (Star's) co-altitude, the true diſtance is leſs than the apparent; except ſometimes when the Sun's alt. is under 10 degrees. But if the diſtance exceed 90 deg. the above holds good in general.

2. When the Moon is the lower body, the true diſtance is always leſs than the apparent; and the true diſtance can never exceed the apparent, but when the Moon is the higher body.

3. The true diſtance, however, is not always greater than the apparent when the Moon is the higher body, as that takes place only when the ſine of the Moon's altitude has a greater proportion to that of the Sun's, than radius has to the coſine of the obſerved diſtance; which alſo muſt evidently become the converſe, when the diſtance exceeds 90 degrees. Theſe obſervations are all deducible from a due conſideration of the figure.

This conſtruction may be apparently rendered more ſimple by drawing only the lines *CZ*, *Cz*, making the angle *ZCz* = the apparent diſtance, and taking *CM*, *CS*, the ſines of the Moon's and Sun's (Star's) altitude reſpectively; but it is well known that the ſines cannot be taken off with that correctneſs as the chords, unleſs when the altitudes are low; this method, therefore, will not be found ſo convenient in general. The reaſon of this latter method is evident, for *CS* is the ſine of *EP*, and *CM* the ſine of *DL*. Hence Mr. Kelly's conſtruction; which, in this reſpect, appears to be eſſentially the ſame with Mr. Mackay's.

EXAMPLES.

# EXAMPLES.

## EXAMPLE I.—*From* p. 29, Fig. 2.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| GIVEN | App. diſt. | 81 | 23 | 38 | Req. the true diſtance. |
| | Sun's alt. | 27 | 43 | 0 | |
| | Moon's alt. | 48 | 22 | 0 | |
| | Hor. par. | 0 | 58 | 45 | |

| | | ° | ′ | ″ | | ° | ′ | ″ |
|---|---|---|---|---|---|---|---|---|
| To rad. *CD* | *Zz* is the chord of | 81 | 23 | 38 | | | | |
| | *DL* | 48 | 22 | 0 | | | | |
| | *EP* | 27 | 43 | 0 | App. diſt. | 81 | 23 | 38 |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| *MN*, meaſured on the chords, is $20\frac{1}{7}'$, which is here | — | 0 | 20 | 8 |
| And 63 $(62—58\frac{3}{4})$ $3\frac{1}{4}$ :: $20\frac{1}{7}$ : $1\frac{1}{20}$ nearly, | + | 0 | 1 | 3 |
| The true diſtance (leſs than the appar.) | | 81 | 4 | 33 |

Which agrees with the calculation within 2 ſeconds.

## EXAMPLE II.—*From* p. 34, Fig. 3.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| GIVEN | App. diſt. | 42 | 0 | 0 | Req. the true diſtance. |
| | Sun's alt. | 14 | 32 | 33 | |
| | Moon's alt. | 42 | 11 | 48 | |
| | Hor. par. | 0 | 54 | 47 | |

| | | ° | ′ | ″ | | ° | ′ | ″ |
|---|---|---|---|---|---|---|---|---|
| To rad. *CD* | *Zz* is the chord of | 42 | 0 | 0 | | | | |
| | *DL* | 42 | 11 | 48 | | | | |
| | *EP* | 14 | 32 | 33 | App. diſt. | 41 | 59 | 57 |

| | | ° | ′ | ″ |
|---|---|---|---|---|
| *MN*, meaſured on the chords, is 22′, which is | + | 0 | 22 | 0 |
| And 54 : $(54\frac{3}{4}—53)$ $1\frac{3}{4}$ :: 22 : $\frac{3}{4}$ very nearly | + | 0 | 0 | 44 |
| The true diſtance (greater than the apparent) | | 42 | 22 | 41 |

Agreeing extremely exact with the computation.

EXAMPLE

## EXAMPLE III.—*From* p. 40, Fig. 4.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| GIVEN | App. diſt. | 113 | 14 | 56 | Req. the true diſtance. |
| | Sun's alt. | 14 | 11 | 57 | |
| | Moon's alt. | 24 | 48 | 0 | |
| | Hor. par. | 0 | 59 | 39 | |

| | | | | | | ° | ′ | ″ |
|---|---|---|---|---|---|---|---|---|
| To rad. *DC* | *Zz* is the chord | 113 | 14 | 56 | | | | |
| | *EP* | 14 | 11 | 57 | | | | |
| | *DL* | 24 | 48 | 0 | App. diſt. | 113 | 14 | 56 |
| | *MN*, meaſured on the chords, is 25′, which is | | | | — | 0 | 25 | 0 |
| | And 63 : (62—59⅔) 2⅓ :: 25 : 1 nearly | | | | + | 0 | 1 | 0 |
| | The true diſtance (leſs than the apparent) | | | | | 112 | 50 | 56 |

Differing from the computation only four ſeconds.

## EXAMPLE IV.—*From* MACKAY on the Long. p. 118, Fig. 5.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| GIVEN | App. diſt. | 68 | 35 | 40 | Req. the true diſtance. |
| | Sun's alt. | 33 | 31 | 0 | |
| | Moon's alt. | 30 | 44 | 0 | |
| | Hor. par. | 0 | 59 | 17 | |

| | | | | | | ° | ′ | ″ |
|---|---|---|---|---|---|---|---|---|
| To rad. *CD* | *Zz* is the chord of | 68 | 35 | 40 | | | | |
| | *DL* | 30 | 44 | 0 | | | | |
| | *EP* | 33 | 31 | 0 | App. diſt. | 68 | 35 | 40 |
| | *MN*, meaſured on the chords, is 23′, which is | | | | — | 0 | 23 | 0 |
| | And 63 : (62—59¼) 2¾ :: 23 : 1 nearly | | | | + | 0 | 1 | 0 |
| | The true diſtance (leſs than the appar.) | | | | | 68 | 13 | 40 |

Differing only 5 ſeconds from the reſult by Mr. Mackay's method.

EXAMPLE

## EXAMPLE V.—*From* the REQUISITE TABLES, p. 41, Fig. 6.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| GIVEN | Moon's diſt. from Star | 50 | 8 | 41 | Req. the true diſtance. |
| | Moon's alt. | 55 | 56 | 0 | |
| | Star's alt. | 19 | 18 | 0 | |
| | Moon's hor. par. | 0 | 60 | 5 | |

| | | | | |
|---|---|---|---|---|
| To rad. *DC* | *Zz* is the chord of | 50 | 8 | 41 |
| | *DL* | 55 | 56 | 0 |
| | *EP* | 19 | 18 | 0 |

*MN*, on the chords, is $15\frac{5}{8}$, here

And $54 : (60\frac{1}{12} - 53) :: 15\frac{5}{8} : 2\frac{1}{20}$ nearly

| | ° | ′ | ″ |
|---|---|---|---|
| App. diſt. | 50 | 8 | 41 |
| + | 0 | 15 | 37 |
| + | 0 | 2 | 3 |
| The true diſtance (greater than the appar.) | 50 | 26 | 21 |

Differing from the Example in the R. T. only 8 ſeconds.

## EXAMPLE VI.—*From* the REQ. TABLES, p. 31, Fig. 7.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| GIVEN | Diſt. of centres | 103 | 29 | 27 | Req. the true diſtance. |
| | Sun's alt. | 19 | 3 | 36 | |
| | Moon's alt. | 41 | 6 | 2 | |
| | Hor. par. | 0 | 58 | 35 | |

| | | | | |
|---|---|---|---|---|
| To rad. *CD* | *Zz* is the chord of | 103 | 29 | 27 |
| | *DL* | 41 | 6 | 2 |
| | *EP* | 19 | 3 | 36 |

*MN*, meaſured on the chords, is $27\frac{2}{3}$, here

And $63 : (62' - 58'\ 35'')\ 3\frac{5}{12} :: 27\frac{2}{3} : 1\frac{1}{2}$ nearly

| | ° | ′ | ″ |
|---|---|---|---|
| App. diſt. | 103 | 29 | 27 |
| + | 0 | 27 | 40 |
| + | 0 | 1 | 30 |
| The true diſtance (leſs than the appar.) | 103 | 3 | 17 |

Agreeing with the Example in the R. T. within 2 ſeconds only.

## *General Directions reſpecting the* SEXTANT*; of obſerving the diſtance between the Moon and a celeſtial Object; and of the manner of taking a ſet of Lunar Obſervations.*

## OF THE SEXTANT.

THE Sextant is conſtructed on the ſame principles as the Quadrant, having its arch extended to 60°, which, becauſe of the double reflection, is divided into 120°. As the Sextant is principally deſigned for determining the angular diſtance of the Moon from the Sun, or a fixed Star, it is therefore more nicely conſtructed, and furniſhed with ſome additional parts that are wanting in the Quadrant.

This inſtrument, which is commonly made of metal, has a wooden handle attached to the back of the frame, by which, when obſerving the diſtance between two objects, it is to be held with one hand, while the other is employed in regulating the index. The degrees on the limb are commonly divided into three equal parts, containing each therefore 20 minutes; and the index ſcale is divided ſo as to ſhew half minutes, and ſometimes the ſixth of a minute. The index is furniſhed with a tangent ſcrew, by which it may be moved ſlowly and regularly; and therefore the contact of the limbs of any two objects, may be made as perfect as the eye is able to diſtinguiſh, when aſſiſted with one of the teleſcopes which uſually accompany this inſtrument.

In the beſt Sextants, the lower half of the index glaſs is ſilvered, and the back ſurface of the other half ground and painted black. A thin plate of braſs, equal in length and breadth to the ſilvered part of the ſpeculum, and moving on an axis, is occaſionally raiſed before that part of the index glaſs, the reflection being then ſeen from the poliſhed ſurface of the upper half of that glaſs; ſo that by this means any error which might probably ariſe from the double reflections, or the want of paralleliſm in the two ſurfaces, is avoided. This, among many others, is an improvement we owe to the Rev. Dr. MASKELYNE.

In ſome Sextants the horizon glaſs is fixed to the inſtrument, and is therefore incapable of adjuſtment; in theſe it is neceſſary to aſcertain with great accuracy the index error. The coloured glaſſes are ſimilar to thoſe in the Quadrant, being uſually four in number; the Sextant has, however, generally three more, which are placed occaſionally on the farther ſide of the horizon glaſs. Theſe are particularly uſeful in taking the Sun's altitude by the artificial mercurial horizon at ſea or land; alſo in finding the index error, by means of the Sun.

The Sextant ſhould be furniſhed with two teleſcopes, one to ſhew objects in their natural poſition, and the other of the common aſtronomical conſtruction; with a tube alſo without glaſſes. By means of theſe, the line of ſight may be rendered parallel to the plane of the inſtrument; and the contact of the limbs of any two objects more accurately determined. The tube, or either teleſcope, is to be ſcrewed into a braſs ring, which is connected with another braſs ring, by means of two ſcrews, in ſuch a manner as to raiſe or lower the teleſcope, in order that the line of collimation may be directed to a proper part of the horizon glaſs. A circular cell, containing a plate, in which are three coloured glaſſes, ſometimes accompanies the Sextant: This cell is to be ſcrewed on the eye end of the tube, or of either teleſcope; the edge of the plate projects a little beyond the cell on one ſide, and is moveable by the finger, ſo as the perforation, or either coloured glaſs, may be brought oppoſite to the circular aperture in the cell.

### *Examination of the Sextant.*

Every Mariner ought to be particularly careful reſpecting the accuracy of his inſtrument; or to be well aſſured of the corrections for any errors to which it may be liable; as a neglect or inattention of this kind muſt render the beſt obſervations uncertain, and a dependance thereon evidently attended with danger.

The imperfections of a Sextant may ariſe from various parts of its conſtruction;—the primary and intermediate diviſions of the limbs; the diviſions of the index ſcale; the paralleliſm of the ſurfaces of the mirrors, and of the ſkreens or coloured glaſſes, with the purity of their mediums; and laſtly, which is of equal importance, the workmanſhip of the whole, which, if not carefully executed by a good artiſt, will render the inſtrument of little value.

The length of the ſcale on the limb ſhould be adapted to the radius of the Sextant; which may be aſcertained in the following manner. Meaſure the diſtance between the centre of motion of the index, and the exterior circular line bounding the diviſions, and apply this diſtance to a ſcale of equal parts.

Multiply

the number anſwering to this diſtance on the ſcale by ·77256, and the product will give the extent between 0° and 90°, or between 30° and 120°, on the limb. The diviſions on the limb may alſo be verified thus: On a level beach or piece of ground, let two rods be placed in a vertical poſition, at a convenient and nearly equal diſtance from the obſerver; adjuſt the Sextant by the left hand rod, and take the exact angular diſtance between the rods; now meaſure the diſtance between the centre of the index glaſs and each rod, and alſo the diſtance between the rods, as accurately as poſſible. Hence the angle at the centre of the index glaſs may be found by trigonometry. the difference between which and that by obſervation, will be the error of the ſcale at that particular diviſion. By altering the diſtance of the rods, and proceeding as before, it will be found if the error be proportionable to the arc; and by this means a table of errors may be made for any inſtrument under examination.

The intermediate diviſions may be examined by means of the index ſcale, if it be of a proper length, which is eaſily diſcovered by multiplying the radius of the Sextant by ·05526, if the ſcale takes in 6° 20′, but by ·06108 if equal to 7°. Now if one of the extreme diviſions of the index ſcale be put to any on the limb, the other extreme diviſion will coincide with a diviſion on the limb; and in this manner may the whole ſcale be verified. The accuracy of the diviſions of the index ſcale may be eaſily aſcertained, by obſerving if the differences of coincidence between theſe diviſions and thoſe on the limb be regular, and that no two diviſions on the index coincide with two, at the ſame time, on the limb, the extreme diviſions excepted.

Both ſurfaces of each mirror ſhould be perfect planes, and ſtrictly parallel to each other. The firſt of theſe requiſites may be verified by means of two diſtinct objects, as follows.—Move the index, till both objects are exactly in contact at the upper edge of the ſilvered part of the horizon glaſs; now the plane of the Sextant being ſtill kept in the ſame poſition, move it, in its own plane, ſo as to cauſe the united images to move along the line of ſeparation of the horizon glaſs; and if in this motion the images continue united, the reflecting ſurface is a good plane; otherwiſe the plane is imperfect. The paralleliſm of the planes of the reflecting ſurfaces may be examined, by viewing the image of the flame of a candle reflected obliquely by the glaſs; for if that image appears ſingle and well defined about the edge, the ſurfaces of the glaſſes are parallel to each other; but if the reflected image is repeated, the planes of the glaſs are inclined, and produce an erroneous angle of reflection.

The coloured glaſſes ſhould be free of veins, and have their planes alſo true and parallel. The firſt defect will be immediately ſeen by viewing the Sun through them; and the latter may be diſcovered by the following method. Obſerve the Sun's altitude when near the meridian, and ſecure the index; then turn the coloured glaſs with its other ſurface towards the index glaſs, and if there be no difference in the altitude, the planes of the glaſs are parallel to each other; if not, make the contact of the Sun's limb and horizon perfect, and half the difference of altitudes will be the error of the glaſs. The lower the Sun's meridian altitude the better.

## *Adjuſtments of the Sextant.*

A Sextant is adjuſted by ſetting the mirrors perpendicular to its plane, and parallel to each other, when the index is at Zero, and rectifying the poſition of the line of collimation.

The firſt adjuſtment is effected thus: Put the index to about 60°, and hold the plane of the Sextant nearly parallel to the horizon, the limb being from the obſerver: then, if the reflected limb of the inſtrument by the ſpeculum appears to be exactly in the ſame plane with that ſeen directly, the glaſs is truly perpendicular to the plane of the Sextant. But if the limbs are not in the ſame plane, turn the ſcrews in the plate behind the ſpeculum till they are apparently brought into that poſition, and the glaſs will be adjuſted.

To ſet the horizon glaſs perpendicular to the plane of the Sextant,—bring the beginning of the diviſion on the index to zero on the limb (the index glaſs being previouſly adjuſted), and hold the plane of the inſtrument horizontally; then, if the reflected horizon and that ſeen directly are in the ſame ſtraight line, the glaſs is truly perpendicular; otherwiſe, turn the adjuſting ſcrew of the horizon glaſs till the coincidence be perfect.

The parallеliſm of the horizon glaſs and the ſpeculum may be thus examined.—Let the firſt diviſion on the index be ſet to zero on the limb, and ſecured by the ſcrew in that poſition; and make the coincidence of theſe diviſions accurate by the index adjuſting ſcrew, uſing occaſionally the magnifying lens. Fix the teleſcope in its ſupport, and, by means of its ſcrew, let it be turned till its field is biſected by the line which ſeparates the ſilvered and tranſparent parts of the horizon glaſs; then, keeping the ſextant in a vertical poſition, direct the ſight to the horizon, and if the reflected and direct horizons do not coincide, releaſe the ſcrew which lies nearly behind the ſupport of the teleſcope, and, by means of the lever, make the coincidence of the horizons perfect, and the horizon glaſs will be properly adjuſted.

But as it is difficult to obtain a true coincidence by this means, the horizons may be brought to coincide by turning the adjuſting ſcrew of the index, and the difference between the two zeros will be the index error. Dr. *Maskelyne* gives us an excellent method in the Requiſite Tables, of finding the index error; which is by meaſuring the diameter of the Sun or Moon twice, with a motion of the index in contrary directions. If both meaſures are taken either to the right or left of o on the limb, half their ſum will be the index error, and is ſubtractive or additive accordingly. But if one of the meaſures is taken to the right, and the other to the left of o, half the difference is the index error, being additive when the diameter meaſured to the left of o exceeds that meaſured to the right; otherwiſe ſubtractive. In many Sextants the horizon glaſs is fixed; the index error muſt therefore be found and conſidered as a conſtant quantity, to be applied to all angles meaſured by that inſtrument.

The laſt adjuſtment of the Sextant is the paralleliſm of the line of collimation with the plane of the inſtrument. To effect this, bring the two parallel wires in the eye end of the teleſcope, parallel to the plane of the Sextant, and ſelect two celeſtial objects, whoſe diſtance may be 90° or more; and, at the wire neareſt the plane of the inſtrument, make the contact of the limbs as perfect as poſſible, and there ſecure the index. Now move the Sextant till the objects appear at the other wire; and if the ſame limbs are in contact, the line of collimation, or axis of viſion, is true. But if the limbs are either apparently ſeparated, or partly cover each other, correct half the error by the ſcrews in the circular part of the ſupporter, one of which is above, and the other between the teleſcope and Sextant; then turn the index adjuſting ſcrew till the limbs are in contact, and proceed as before till no error remains. The error of the line of collimation in a Sextant being known, the reſulting error of obſervation may be obtained by computation; or it may be had by inſpection from a table calculated for this purpoſe by Mr. *Mackay*, in his valuable book on the longitude.

## *To obſerve the Distance between the Sun and any celeſtial Object.*

In obſerving the angular diſtance between the Moon and the Sun, or a fixed Star, the Sextant muſt be ſo held by the obſerver, that its plane produced may paſs through his eye and both objects; and the reflected image of the moſt luminous of the two, is to be brought in contact with the other ſeen directly. It is evident, therefore, that when the brighteſt object is to the right the other, the face of the Sextant muſt be held upwards; but if to the left, downwards: In the former poſition, the inſtrument ſhould be held with the right hand, and in the latter with the left; the other hand being employed in regulating the index.

If the object be the Sun,—having brought the wires in the teleſcope parallel to the plane of the Sextant, and (if the Sun be very bright) raiſed the ſkreen before the ſilvered part of the ſpeculum; direct the teleſcope either to the tranſparent part of the horizon glaſs, or to the line which ſeparates the ſilvered and tranſparent parts of that glaſs, according to the brightneſs of the Sun, and turn down one of the coloured glaſſes. Then having brought the inſtrument, as above remarked, into its proper poſition, look directly through the teleſcope at the Moon, and move the index till the limb of the Sun is nearly in contact with the enlightened limb of the Moon; there ſecure the index, and by a gentle motion of the inſtrument, let the image of the Sun paſs alternately by the Moon; and where the limbs appear the neareſt to each other, make the coincidence perfect by the index adjuſting ſcrew. Then will the index ſhew on the limb (uſing the magnifying glaſs) the angular diſtance between the limbs of the Sun and Moon.

If the object be a Star,—direct the teleſcope to the line of ſeparation of the ſilvered and tranſparent parts of the horizon glaſs, and if the Moon is very bright, turn down the lighteſt coloured ſkreen. Look directly through the teleſcope at the Star, obſerving the poſition of the Sextant as before directed, and move the index till the Moon's enlightened limb appears by reflection to be nearly in contact with the Star; then ſecure the index, and by the adjuſting ſcrew make the coincidence perfect, and the index will ſhew the obſerved diſtance between the Moon's enlightened limb and the Star.

## *The manner of taking a ſet of Lunar Obſervations.*

To take a ſet of Lunar Obſervations in a regular and accurate manner, three aſſiſtants are neceſſary,—two to obſerve the altitudes of the objects, at the ſame time that the diſtance is taken by the principal obſerver: the other aſſiſtant is to mark preciſely, by a watch ſhowing ſeconds, the time when the obſervations are made. If the Sun or Star is at a proper diſtance from the meridian, the time may be deduced from the altitude obſerved at the ſame time with the diſtance, and therefore the watch is unneceſſary; but if the object with which the Moon is compared be too near the meridian, the watch is indiſpenſibly neceſſary, in order to connect the obſervations for determining the apparent time at the ſhip, and the longitude, with each other.[*] Previous to the obſervations, let the Sextants and Quadrants be accurately adjuſted, or their errors of adjuſtments found, and their indices ſet to the eſtimate diſtance and altitudes reſpectively. Now, the obſervers being all prepared and conveniently ſituated, they are all to begin to obſerve at the ſame time; and when the principal obſerver has obtained a perfect coincidence of the limbs of the objects, he informs his aſſiſtants; when the writer immediately puts down the ſecond, minute, and hour; with the diſtance, and altitudes of the objects. In this manner the obſervations are repeated, till four or five different ſets are obtained, which may be eaſily performed in ſix or eight minutes. The mean of each ſet of obſervations is then to be taken, and the longitude of the Ship deduced from thence, in the ſame manner as from a ſingle ſet.

Several examples illuſtrative of this method may be ſeen in the *Requiſite Tables*, from p. 38 to the end.

An expert obſerver, however, may diminiſh the number of his aſſiſtants, and even, in caſe of neceſſity, might be capable of making all the neceſſary obſervations himſelf, with a tolerable degree of accuracy.—Let two or three altitudes of the limbs of the Sun and Moon be taken, with the time per watch of each: then obſerve five or ſix diſtances between the limbs of theſe objects, and laſtly, ſeveral altitudes are again to be obſerved. Find the mean of each ſet of obſervations, and reduce the altitudes to the *time of the mean diſtance*; which may be effected, without any ſenſible error, by even proportion, provided the intervals of obſervation are ſhort, as the change in altitude may be then ſuppoſed uniform. Hence will a complete ſet of obſervations be obtained.

The following imaginary example will illuſtrate the method of reducing the altitudes to the time of the mean diſtance.

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[*] *Vide* Remark in the Requiſite Tables, p. 42.

| | Time per watch.<br>*H. M. S.* | | ° ′ | Means.<br>*h* ′ ″ | ° ′ ″ |
|---|---|---|---|---|---|
| | 2 28 10 | Alt. S. *L. L.* | 46 12 | | |
| | 29 20 | | 46 10 | | |
| Ob. I | 2 \| 57 30 | | 2 \| 22 | 2 28 45 | 46 11 0 |
| | 28 45 | | 11 | | |
| | 31 20 | Alt. M. *U. L.* | 16 6 | | |
| | 32 16 | | 16 4 | | |
| Ob. II. | 2 \| 63 36 | | 2 \| 10 | 2 31 48 | 16 5 0 |
| | 31 48 | | 5 | | |
| | 34 19 | Diſt. neareſt limbs | 41 12 | | |
| | 35 28 | | 41 10 30 | | |
| | 36 30 | | 41 10 0 | | |
| Ob. III. | 3 \| 106 17 | | 3 \| 32 30 | 2 35 29 | 41 10 50 |
| | 35 29 | | 10 50 | | |
| | 39 38 | Alt. *S. L. L.* | 45 52 | | |
| | 40 42 | | 45 48 | | |
| Ob. IV. | 2 \| 80 20 | | 2 \| 91 40 | 2 40 10 | 45 50 0 |
| | 40 10 | | 45 50 | | |
| | 42 38 | Alt. M. *U. L.* | 15 48 | | |
| | 43 36 | | 15 45 | | |
| Ob. V. | 2 \| 86 14 | | 2 \| 31 33 | 2 43 7 | 15 46 30 |
| | 43 7 | | 15 46 30 | | |

| | *h* ′ ″ | | ° ′ | | *h* ′ ″ | | ′ ″ |
|---|---|---|---|---|---|---|---|
| | 2 28 45 | | 46 11 | | 2 28 45 | | |
| | 2 40 10 | | 45 50 | | 2 35 29 | | |
| As | 11 25 | : | 21 | :: | 6 44 | : | 12 30 |
| Sun's alt. at 2*h* 28′ 45″ | | | | | | | 46 11 0 |
| Reduced alt. Sun's *L. L.* | | | | | | | 45 58 30 |

| | *h* ′ ″ | | ° ′ ″ | | *h* ′ ″ | | ′ |
|---|---|---|---|---|---|---|---|
| | 2 31 48 | | 16 5 0 | | 2 31 48 | | |
| | 2 43 7 | | 15 46 30 | | 2 35 29 | | |
| As | 11 19 | : | 18 30 | :: | 3 41 | | 6 |
| Moon's alt. at 2*h* 31′ 48″ | | | | | | | 16 5 |
| Reduced alt. Moon's *U. L.* | | | | | | | 15 59 |

Hence we have the following ſet of obſervations.

| Time p. watch | Diſt. neareſt *L.*'s *S.* and *M.* | Alt. Sun's *L. L.* | Alt. Moon's *U. L.* |
|---|---|---|---|
| 2*h* 35′ 29″ | 41° 10′ 50″ | 45° 58′ 30″ | 15° 59′ |

If the Sun be near the meridian at the time the diſtance is taken, it has been before remarked, the apparent time cannot be deduced from thence with a ſufficient degree of accuracy; if, therefore, the error of the watch is not known, other obſervations muſt be taken before or after the obſervation of the diſtance, in order to aſcertain that error with preciſion. But if the ſet of obſervations be made any time between half an hour after ſun-riſe and ten o'clock in the forenoon, or between two in the afternoon, and half an hour before ſun-ſet,—the apparent time may be obtained from the Sun's altitude; in which caſe the watch is not abſolutely neceſſary. In finding the lunar diſtances with the ſtars, though an obſerver be not much acquainted with them, he will not find it difficult to diſtinguiſh the ſtar with which the Moon is to be compared; for, knowing the time of obſervation, and the ſhip's longitude by account, the approximate time at Greenwich is alſo known, to which time the diſtance *nearly* between the Moon and given Star will be found in the Nautical Almanac. If the index of the Sextant, therefore, be ſet to this diſtance, and the inſtrument ſo held that its plane may be at right angles to the line joining the Moon's cuſps, and a ſlow vibratory motion then given to it, the Star will be immediately diſcovered in the ſoliated part of the horizon glaſs, being uſually one of the greateſt magnitude in that part of the heavens.

## FINAL REMARK.

The Mariner muſt be careful to obſerve, in uſing the *Nautical Almanac*, to make a proper diſtinction between the aſtronomical, civil, and nautical reckoning of time; as the nautical, or ſea mode is 24 hours, or one whole day, and the civil twelve hours, in advance of the aſtronomical, at the commencement of the day. Thus, May 28th, $9^h\ 50'$ in the forenoon, civil time, is May 27th, $21^h\ 50'$ aſtronomical time, and May 28th, $9^h\ 50'$ *A. M.* nautical time: Alſo, May 28th, $9^h\ 50'$ in the afternoon, civil time, is May 28th, $9^h\ 50'$ aſtronomical, and May 29th, $9^h\ 50'$ *P. M.* nautical; the ending of the nautical, the noon of the civil, and the beginning of the aſtronomical day, being all at the ſame time.

THE END.

# *PROSPECTUS*

OF A

# GENERAL COURSE OF LECTURES,

On the moſt uſeful and entertaining Parts of

# EXPERIMENTAL PHILOSOPHY,

*COMPRISED IN TWELVE EXHIBITIONS.*

BY HENRY CLARKE,

LATE PRÆLECTOR ON MATHEMATICS AND PHILOSOPHY, IN THE COLLEGE OF ARTS AND SCIENCES, AT MANCHESTER.

*Philosophia Mater omnium bonarum Artium est.*

## LECTURE I.

### *ELECTRICITY.*

THE nature of the electric fluid: the vitreous or poſitive, and the reſinous or negative powers explained.—The conſtruction of the parts of the machine, and the manner of collecting the fluid.—Electrics and Conductors, what.—The conſtruction of the Leyden phial—charged and diſcharged—rationale of; an exploſion with the balls—ſilently with points—by the human body—by a circuit through many conductors—takes generally the ſhorteſt courſe. Glaſs plate charged and diſcharged; the ſhock given through water—diſcharged through a card—diſcharged but partially through a circuit of ſilk, glaſs, or any electric or non-conductor. Electric attraction and repulſion—exhibited by a variety of experiments. The phenomena of the double bottle explained. The effects of balls and points, by experiments. Mr. Gamble's curious experiment with the ball and leaf. Expanſion or rarefaction of the air, ſhewn by Kinnerſley's electric-air thermometer. The electric orrery, being a beautiful repreſentation of the earth's annual motion round the ſun, the moon's monthly motion round the earth, and the motions of the whole round their common centres of gravity. Medical Electricity; its effects on the human body on the inſulated board. Capillary tube experiment, proving the acceleration of the circulation of the blood by the application of the Electric fluid. How applied to the human body in various caſes—by Dr. Lane's medical bottle—by Dr. Birch's new medical apparatus. The new bottle-director. The Electrophorus explained—experiments with.

## LECTURE II.

### *ELECTRICITY.*

THE nature of poſitive and negative electricity farther illuſtrated—by the prime conductor—by the Leyden phial—by the ſuſpended balls—by the quadrant electrometers. The courſe of the electric fluid rendered viſible to the ſenſes by the univerſal diſcharger; poſitive and negative charge of a jar evidently proved thereby. The ring and bubble experiment. The Electric battery explained, how charged, &c. The nature of conductors to houſes—how preſerved from thunder and lightning; experiments with the Thunder-houſe, Church, &c. to illuſtrate this;—objections by Mr. Wilſon, &c. Experiments of the electric exploſion received by a point within a glaſs tube—applied to the thunder-houſe, to ſhew the inefficacy of points in certain caſes.

### *The Effects of the Electric Battery.*

A quire of paper perforated by the electric fluid ; ſpirits fired by the electric ſpark ; cotton fired ; gun-powder fired ; wire melted ; gold leaf incorporated with glaſs ; tubes burſt by the paſſage of the electric fluid ; houſe ſet on fire, another blown up by the diſcharge of the battery ; piſtol fired by the electric ſpark. Paſſage of the electric fluid proved to be inſtantaneous, in diſcharging two (or more) piſtols thereby through a long circuit. The electric cannon.

## LECTURE III.

### *LUMINOUS ELECTRICITY—(Dark Room).*

THE courſe of the electric fluid rendered viſible by the Leyden phial—poſitive and negative by the diſcharger; the charging and diſcharging ſhewn by the *ſtar* and *bruſh*, with Adams's inſulated phials in various poſitions. Curious experiment, rendering viſible the courſe of the fluid by the partial-coated bottle and apparatus—proving, by an ocular demonſtration, the truth of Dr. Franklin's hypotheſis of the Leyden phial, or any ſupercharged ſurfaces. The electric ſpark viſible in water by an exploſion therein. Jars of water rendered luminous. The luminous balls. The *Aurora borealis*—exhibited by the Leyden vacuum. Adams's luminous conductor, in various poſitions. Prieſtley, Cavallo, and Crawford's curious experiments with exhauſted receivers on the air-pump. The luminous ſpiral. The luminous tube. The ſpotted bottles. The luminous word. The Star,—Comet. Beautiful repreſentations of the conſtellations *Orion* and *Urſa major*.

## LECTURE IV.

### *MAGNETISM.*

THE modern theory of Magnetiſm—various kinds of magnets deſcribed; general laws of attraction and repulſion—illuſtrated by many pleaſing experiments—courſe or direction of the magnetic fluid. Magnetic ſuſpenſion—the facturer—dipping needle—terella explained. The rolling magnet—entertaining experiment with. The magnetic fiſh. Magnetiſm how communicated to iron or ſteel; polarity given, deſtroyed, and reſtored inſtantaneouſly. Variation of the compaſs, annual and diurnal variation of the needle; heat increaſes the diurnal variation weſtward; the whirligigs, a perpetual motion in vacuo; the mode of a perpetual motion exhibited by a combination of magnets. Artificial magnets how made. The magical tube and box. The magical heart.

## LECTURE V.

### *PNEUMATICS, or the Doctrine of Air.*

OF the nature of the atmoſphere, and air in general—conſtruction of the air-pump. Of barometers, thermometers, and hygrometers. The weight and preſſure of the air proved—by the mercurial tube—by an exhauſted receiver—by the hand-glaſs; exhauſted braſs hemiſpheres; the abſurdity of the vulgar notion of what is commonly called ſuction ſhewn; ſhower of quickſilver through the pores of wood; the operation of the common water-pump—water not riſe in vacuo; artificial fountain by the preſſure of the atmoſphere; phials broken by the preſſure of the air; the glaſs bubbles; ſyringe and weights to prove the preſſure of the air upwards; the ſame proved by the inverted jar. The ſpring of the air demonſtrable by various experiments—by the bladder, bubble, egg, Fawkes's figures, balloon, artificial fountain—weights raiſed by the ſpring of air in a bladder—bottle burſt thereby—bladder-glaſs.

## LECTURE VI.

### *PNEUMATICS.*

THE mercurial gauge—curious experiment ſhewing the ſpring of the air to be equal to its weight or preſſure by the riſe of the mercury; fiſh experiment under the exhauſted receiver; water boiled by exhauſtion; air extracted from a vegetable ſubſtance in water; lead and cork in vacuo. Bell in vacuo; tranſition from hence to the doctrine of ſounds; the conſtruction of the ear; the monochord, ventriloquiſt, &c. explained; guinea and feather experiment.

NEW hydroſtatic apparatus deſcribed: Fluids weigh as much in their own element as in air. A body weighed in a fluid loſes apparently as much of its weight as its bulk of the fluid weighs. Of the ſpecific gravities of bodies, air weighed in its natural, rarefied, and condenſed ſtate. The common Hydrometer explained; deſcription and uſe of the patent Hydrometer, Saccharometer, and Lactometer, ſhewing reſpectively the ſtrength or purity of ſpirits, malt-liquor, and milk. Fluids preſs equally in all directions. The preſſure of fluids as their perpendicular height. Light wood made to ſink, and lead to ſwim in water, merely by the preſſure of the fluid. The hydroſtatic paradox. Syphons. Tantalus's cup. Working models of the common pump. Working model of a double forcing-pump, with a *Jet d'eau.*

## LECTURE VII.

### *PNEUMATIC CHEMISTRY, &c.*

EXORDIUM on the nature and chemical properties of Air. Candle extinguiſhed *in vacuo*—remarks thereon. The combuſtion of candles in atmoſpheric air—the air not diminiſhed thereby. Animals killed under a receiver—cauſe explained by the lungs-glaſs. On the reſpiration of animals, and the changes effected on air in paſſing through the lungs. Of aduſt or burnt air. Of the formation of elaſtic aëriform fluids, viz. Hydrogene gas—Oxygene gas—the carbonic acid—azot and nitrous air—exemplified in their actual production—and the criterion of each ſhewn by experiment. Of the muriatic and oxymuriatic gas. Of caloric, or the matter of heat. The decompoſition of water—and its formation by burning Hydrogene gas in a glaſs filled with Oxygene. Iron wire deflagrated in the Oxygene gas. Eudiometrical experiments for determining the purity of air. On mineral waters. The Pyrmont and Buxton waters—how compoſed artificially. Various entertaining experiments with inflammable air. Repreſentations of Volcanic Mountains—curious and pleaſing appearances.

## LECTURE VIII.

### *OPTICS.*

WHEREIN the nature of Viſion, and the Laws of Refraction and Reflection of Light are pleaſingly illuſtrated by various combinations of lenſes and mirrors, in a manner never before attempted in any public Lecture.—The diſſection of a natural eye, compared with an artificial one, whereby its wonderful ſtructure is clearly explained;—the Newtonian doctrine of colours, exhibited by the very priſmatic experiments whereon the great diſcoverer founded his curious and univerſally admired Theory; with a diſplay of the advantages deduced from thence in the perfecting of *artificial* viſion to aſſiſt the *natural*, &c.—Subjects that cannot but afford, to an intelligent audience, the moſt exquiſite entertainment—viz. That of developing the immediate cauſes of corporeal effects, in one of the moſt conſpicuous, and perhaps uſeful of the natural Faculties.

The apparatus illuſtrative of this ſcience—are ſingle lenſes of the various forms—compound and achromatic lenſes,—convex, concave, plain, and cylindric mirrors,—equiangular priſms,—Dollond's ſet of priſms,—artificial eyes, ſcioptric ball,—the Newtonian wheel,—anamorphoſes,—optical deceptions,—microſcopes,—teleſcopes,—megalaſcopes, &c, &c.

# LECTURE IX.

## ASTRONOMY and GEOGRAPHY.

THOUGHTS on the Univerſe; the Ptolemaic ſyſtem; the Tychonic ſyſtem; the Copernican or Solar ſyſtem; the extent and conſtituent parts thereof. Of the Sun; the ſolar *maculæ*; the primary planets; the ſatellites. Of the number, order, diſtance, magnitudes, and periods of the planets—ſuperior and inferior planets and conjunctions; ſtationary, direct, and retrogade motions what, explained by a new piece of machinery in the Orrery; of comets and other phenomena;—the whole illuſtrated by an elegant, modern **PLANETARIUM**, and a **COMETARIUM**.

Of the Moon; its phaſes, period, &c. its libration, nodes, apſides, &c. Of the nature of ſolar and lunar eclipſes, &c explained by diagrams, and the **LUNARIUM**.

Of the earth's diurnal and annual motions; variations in the paralleliſm of its axis, how cauſed. Equation of time what, applied to the regulation of a time-piece. Syderial time, determined from a ſtellar tranſit—by an elegant, newly-conſtructed Tranſit Inſtrument,—by the common Tranſit. Meridian Line,—how accurately drawn,—its uſes. Variation, Azimuth, and Amplitude Compaſs exhibited and explained,—improvement therein. The ſeaſons, length of days, &c.—illuſtrated by the **TELLURIAN**.

# LECTURE X.

THE popular doctrines of **ASTRONOMY** and **GEOGRAPHY**, exhibited by the improved GLOBES, and an elegant **ARMILLARY SPHERE**. A recapitulation of the moſt eſſential parts of theſe ſciences, illuſtrated by a variety of ſmall **MOVEABLE TRANSPARENCIES**,—the whole exhibiting a beautiful and ſtriking diſplay in miniature of the principal celeſtial phenomena relative to Geography and Aſtronomy, viz. The Ptolemaic, Tychonic and Copernican ſyſtems, ſolar and lunar eclipſes, tranſits of Mercury and Venus, the Moon's phaſes, variation in Saturn's ring, Jupiter's belts and ſatellites, ſolar *maculæ*, lunar occultations, the tides, viciſſitudes of the ſeaſons, the accelerated and retarded motions of the comets, &c. &c.—with an honorary illumination, expreſſing the diſcoveries, &c. of the moſt celebrated Aſtronomers.

# LECTURE XI.

## MATHEMATICS.

ON the principles and application of Geometry and Trigonometry—to Menſuration, Navigation, Dialling, &c. and to mechanical and philoſophical purpoſes in general.—Some of the moſt uſeful propoſitions of *Euclid* conſidered; their application in menſuration, gauging, ſurveying, &c. The nature of angles. Trigonometry; its application in various ſciences. An ocular demonſtration of the analogies in ſpherical trigonometry; conic ſections; ordinate figures; principles of fortification; the Platonic bodies. The Pentagraph—explained by an example. Of Quadrants—imperfections pointed out. Hadley's explained. The *complete* Sextant and artificial Horizon, exhibited and elucidated. Menſuration of ſuperficies and ſolids, demonſtrated in a pleaſing manner, by a variety of ſingle and compound bodies, whereby the intricacy of the theorems or rules is removed, in analizing the propoſed figures or bodies by ſections of the moſt ſimple form.

# LECTURE XII.

## MECHANICS.

OF motion in general. The laws of falling bodies; colliſion of bodies; rotatory motion; explained by the whirling table, &c—pendulums; projectiles; gunnery; initial velocity of balls, illuſtrated by a model of the new balliſtic machine at Woolwich. The reſolution and compoſition of forces—elucidated by a proper machine. Of the mechanic powers—method of calculating:—properties of the *heavy* Lever,—Centre of Gravity,—experiment of the double Cone. Model and principles of the Gold Beam. Properties of the Balance. Combination of powers, illuſtrated by an elegant machine from *Ferguſon*:—The whole explained by a neat and extenſive ſet of models.

GENERAL

# *GENERAL SYLLABUS*

OF

# SIX SELECT LECTURES,

## *On Scientifical and Philoſophical Subjects.*

BY H. CLARKE.

### *LECTURE I.*

*THE Theory of the EARTH,*—its internal and external ſtructure,—the various changes the Earth has undergone from its primordial ſtate,—the cauſes and effects of Volcanos,—the origin of Mountains, Rivers, &c. Of WINDS,—the Monſoons. Of Meteors, &c.—Illuſtrated by a variety of apparatus, particularly *Bardin*'s elegant new improved Globes,—the Whirling-table, clearly elucidating *Newton*'s univerſal laws of Central Forces,—with experiments, and illuminated tranſparencies, adapted to the hypotheſes of the moſt eminent Naturaliſts.

### *LECTURE II.*

*PRACTICAL ASTRONOMY,*—the various methods of making obſervations, particularly reſpecting the corrections in Latitude and Longitude. New and conciſe method of finding the Longitude at ſea, —with the rationale. Of Time,—its equation,—applied to the regulation of a Time-piece. Of Tranſits,—their uſes illuſtrated by an elegant newly conſtructed Tranſit Inſtrument,—by the common Tranſit. Meridian line,—how accurately drawn,—its uſes. Variation, Azimuth, and Amplitude Compaſs exhibited and explained,—improvement therein. Of Quadrants,—imperfections pointed out,—Hadley's explained. The complete Sextant and Artificial Horizon exhibited and elucidated. The new Pocket Box Sextant and Artificial Horizon. The Ring Dial. Pocket Compaſs Dial, with Equation Table, &c.

### *LECTURE III.*

*The Theory and Practice of PERSPECTIVE DRAWING,*—familiarized by a variety of Linear Deſigns and moveable ſchemes. The different practical methods of taking Perſpective Views explained. The theory of Aerial Perſpective, illuſtrating the rules of light and ſhade by various examples, and exhibited in an excellent Perſpective Apparatus. The Camera Obſcura,—Perſpective Compaſſes,—Pentagraph, &c.—with the deſcription and uſe of different machines for taking Perſpective Views.

### *LECTURE IV.*

*The Modern Theory of FORTIFICATION,*—exemplified by Diagrams, and a correct model of an hexagonal Fortification,—with the various Out-works, &c. Model of a Temporary or Field Fortification, &c. &c.

### *LECTURE V.*

*The Ancient and Modern Theory of BALLISTICS and GUNNERY.* The laws or Projectiles,—applied to the late practice of Gunnery. The deſcription (by complete models) of Land and Ship Cannons, and Sea Mortars,—their Carriages, &c. The Gunner's Callipers, Quadrant, &c. explained. The new principles of Gunnery, elucidated by various graphical deſcriptions, and a model of the Balliſtic Machine.

### *LECTURE VI.*

*On the Arts of BLEACHING, DYEING, and PERFUMERY.* Introductory diſcourſe on the Acids and Alkalis. Of Muriatic and Oxymuriatic acid Gaſes,—their application in Bleaching. On the colouring principles. The fixed and fugitive Dyes. Of Colour *in grain.* Of the Paſtel, Woad, and Indigo Vats. Enquiries concerning Wool, Silk, Cotton, and Flax. Of the reſpective preparative mordants. —Of the proof liquors for woollen dye. Of the colouring Drugs, and dyeing with Aſtringents.—On the *Spiritus Rector*, or Aroma,—how extracted,—and applied to various ſubſtances. The whole accompanied with experiments, exhibiting the preſent practice of ſome of the moſt eminent in theſe arts in one of the firſt manufacturing towns in England, and with whom H. C. has for ſome years paſt been intimately connected: With the *Rationale* of every proceſs (diſcarding the old maxim of the Empirics, "*Ars est celare artem,*") agreeable to the preſent diſcoveries in philoſophy.

A

# COURSE OF LECTURES

ON

# *PNEUMATIC CHEMISTRY,*

OR, THE

# PRODUCTION, MEDICINAL USE, & APPLICATION

OF

# FACTITIOUS AIRS:

## *By* H. CLARKE.

**Commences immediately on the cloſe of the Courſe on *Experimental Philoſophy*.**

*The Whole being comprised in*

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